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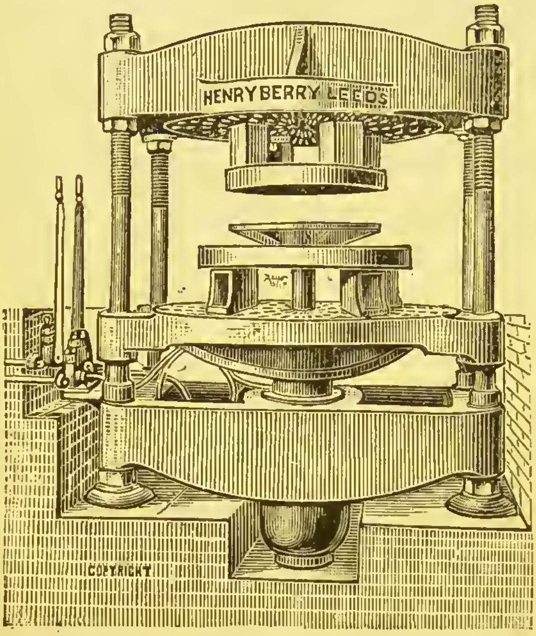

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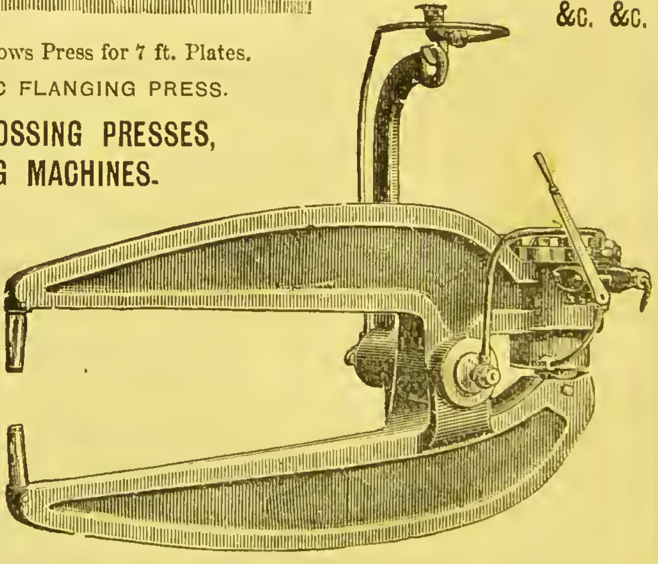

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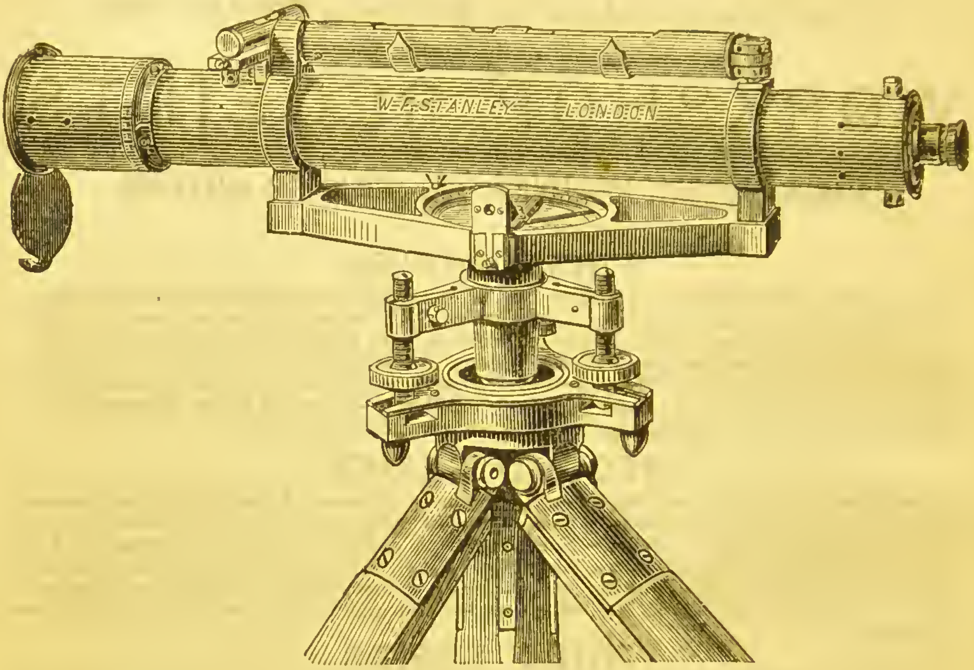

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PREFACE

TO

THE SECOND EDITION.

THE favourable reception of WORKSHOP RECEIPTS by the scientific public during the last twenty years has been most satisfactory to the Publishers, as it has proved to them that the book is a valuable and useful one.

But during this time much additional information has come to hand, many improvements have been made in the Arts, new processes have been invented notably in Photography, and the general progress of twenty years has made much of the matter in the original book obsolete.

The present edition has been carefully revised and brought up to date, and it is hoped that the high reputation gained by the first edition will be maintained by the second.

WORKSHOP RECEIPTS has been compiled with three purposes in view: to serve as a note-book to the small manufacturer; to supply the intelligent workman with information required to conduct a process, foreign perhaps to his habitual labour, but which it is necessary to practise at the time; and to impart to the scientific amateur a knowledge of many processes in the arts, trades and manufactures, which will, it is hoped, render his pursuits the more instructive and remunerative.

The novice would do well to remember that it is the individual skill of the workman in performing many apparently simple operations that renders those operations successful, and that this skill is only obtained through long practice or natural ability. A pre-eminently superior manipulator resembles a poet in that he is "born, not made"; when therefore a receipt is tried for the first time and is not thoroughly successful, the experimentalist should consider, ere he condemns the receipt, how far his own inexperience has contributed to the failure.

Care has been exercised in cases where the practical operation connected with a receipt has been apart from the writer's experience, to have it verified by authority, and the aim throughout has been to render Workshop Receipts a reliable handbook for all interested in Technological pursuits.

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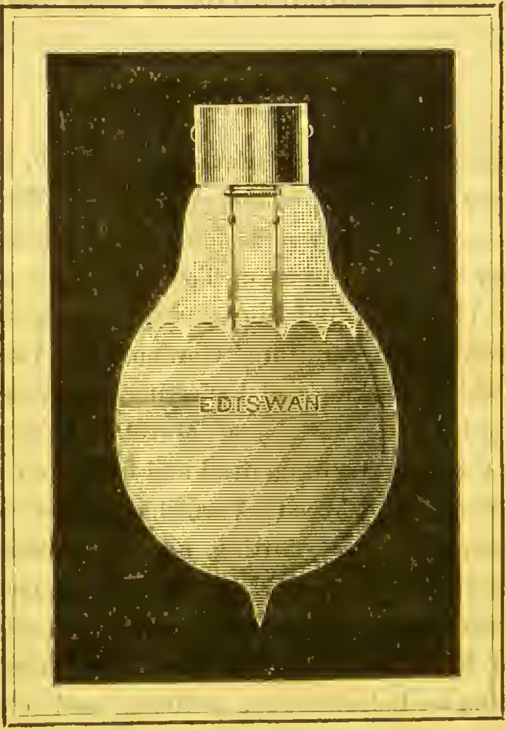

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PAVEMENTS.
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INDEX .. .. *Page* 409

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FIRST SERIES.

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ALCOHOL BARRELS.

Barrels or casks designed to be filled with alcohol, may be made tight by the application of the following solution:— Dissolve in a water bath 1 lb. of leather scraps and 1 oz. of oxalic acid, in 2 lb. of water, and dilute gradually with 3 lb. of warm water. Apply this solution to the inside of the barrel, where, by oxidation, it will assume a brown colour, and become insoluble in alcohol. This coat closes all the pores of the wood, and does not crack or scale off.

ALLOYS.

(iii. 1; v. 76, 198.)

Aluminium Bronze.—100 parts copper and 10 aluminium, measured by weighing, when combined is a durable alloy, which may be forged and worked in the same manner as copper, and is the same colour as pale gold. 80 parts copper, 19 zinc, and 1 aluminium, form a good durable alloy. (See also iii. 11.)

Babbitt's Attrition Metal.—Melt separately 4 lb. of copper, 12 lb. best quality tin, 8 lb. regulus of antimony, and 12 lb. more of tin while the composition is in a melted state. Pour the antimony into the tin, then mix with the copper away from the fire in a separate pot.

In melting the composition, it is better to keep a small quantity of powdered charcoal on the surface of the metal. The above composition is called "hardening." For lining-metal, take 1 lb. of hardening and melt it with 2 lb. of tin, which produces the lining-metal for use. Thus the proportions for lining-metal are, 4 lb. of copper, 8 lb. of regulus of antimony, and 96 lb. of tin.

The article to be lined, having been cast with a recess for the lining, is to be nicely fitted to a "former," which is made of the same shape as the bearing. Drill a hole in the article for the reception of the metal, say a half or three-quarters of an inch, according to the size of it. Coat over the part not to be tinned with a clay wash, wet the part to be tinned with alcohol, and sprinkle on it powdered sal-ammoniac; heat it till a fume arises from the sal-ammoniac, and then immerse in melted tin, taking care not to heat it so that it will oxidise. After the article is tinned, should it have a dark colour, sprinkle a little sal-ammoniac on it, which will make it a bright silver colour. Cool it gradually in water, then take the "former," to which the article has been fitted, and coat it over with a thin clay wash, and warm it so that it will be perfectly dry; heat the article until the tin begins to melt, lay it on the "former" and pour in the metal, which should not be so hot as to oxidise, through the drilled hole, giving it a head, so that as it shrinks it will fill up. After it has sufficiently cooled, remove the "former."

A shorter method may be adopted when the work is light enough to handle quickly; namely, when the article is prepared for tinning, it may be immersed in the lining metal instead of the tin, brushed lightly in order to remove the sal-ammoniac from the surface, placed immediately on the former and lined at the same heating. (See also iii. 41.)

Brass.—The best plan of melting brass is to melt the copper in a black-lead crucible first, *dry* the zinc as much as possible, and immerse the whole of the zinc into the copper when the latter is not hotter than barely to continue fluid. Drop a piece of borax the size of a walnut into the pot. When the surface of the hot metal is kept covered by fine charcoal, or by borax, it is prevented from burning, and the smallest loss of zinc is sustained.

The melting together of tin and copper is less difficult than that of zinc and copper, because tin is not so liable to evaporate as zinc, and little metal is lost. The appearance of the alloy may be improved by covering the melted metal with about one per cent. of dried potash; or, better still, a mixture of potash and soda. This flux has a remarkable influence on the colour, and particularly on the tenacity of the alloy. The former becomes more red, and the latter stronger. The scum forming on the surface by this addition ought to be removed before the metal is cast. Tin and copper are liable to separation in cooling: this can be prevented, at least partly, by turning the mould containing the fluid metal, and keeping it in motion until it is chilled.

Copper and lead unite only to a certain extent: 3 lead and 8 copper is ordinary pot metal. All the lead may be retained in this alloy, provided the object to be cast is not too thick. When the cast is heavy, or much lead is used, it is pressed out by the copper in cooling. 1 lead, 2 copper, separates lead in cooling—it oozes out from the pores of the metal: 8 copper and 1 lead is ductile; more lead renders copper brittle. Between 8 to 1 and 2 to 1 is the limit of copper and lead alloys. All these alloys are brittle when hot or merely warm.

Equal parts of copper and silver and 2 per cent. of arsenic form an alloy similar to silver, a little harder, however, but of almost equal tenacity and malleability. Antimony imparts a peculiar beautiful red colour to copper, varying from rose-red in a little copper and much antimony, to crimson or violet when equal parts of these metals are melted together.

Common brass for castings: 20 copper, $2\frac{1}{2}$ tin, $1\frac{1}{4}$ zinc.

Hard brass for castings: 25 copper, $4\frac{1}{2}$ tin, 2 zinc.

Red brass for fine castings: 24 copper, 5 zinc, 1 bismuth; add the bismuth last before pouring off.

Red brass for turning: (*a*) 24 copper, 5 zinc, $\frac{1}{2}$ lead; add the lead last before pouring off. (*b*) 32 copper, 10 zinc, 1 lead. (*c*) 160 lb. copper, 50 lb. zinc, 10 lb. lead, 44 oz. antimony.

Rolled brass: 32 copper, 10 zinc, $1\frac{1}{2}$ tin.

Yellow brass: (*a*) 70 copper, 30 zinc. (*b*) 20 lb. copper, 10 lb. zinc, 1 to 5 oz. lead added just before pouring.

Brightening and Colouring Brass.—The work to be brightened and coloured is first annealed in a red-hot muffle, or over an open fire, allowing the cooling to extend over one hour; the object of the heating being to remove the grease or dirt that may have accumulated during the process of fitting. Soft soldered work, however, must be annealed before fitted together, and afterwards boiled in a lye of potash; this is also done with work having ornamental surfaces. Next, it is immersed in a bath of diluted oil of vitriol or aquafortis, which may be made with two or three parts of water, and one of acid; but the old acid that contains a small quantity of copper, in solution, is frequently preferred. The work is allowed to remain in this liquid for one or two hours, according to the strength of the acid; it is then well rinsed in water, and scoured with sand applied with an ordinary scrubbing brush, and washed. The pickling bath is made by dissolving one part of zinc in three parts of nitric acid of 36° B. in a porcelain vessel, and adding a mixture of eight parts of nitric acid, and eight parts of oil of vitriol. Heat is then applied, and when the liquid is boiling the work is plunged into it for half a minute, or until the violent development of nitrous vapour ceases, and the surface is getting uniform. Then it is plunged into clean water, and well rinsed, to remove the acid. The ordinary dark greyish-yellow tint, which is thus very often produced, is removed on immersing the work again in aquafortis for a very short time. Then it is plunged into clean or slightly alkaline water, well rinsed to remove the acid, and plunged into warm dry beech or boxwood saw-dust, and rubbed until quite dry. To prevent the action of the atmosphere it is lacquered; if a green tint is to be produced, the lacquer is coloured with turmeric. A dark greyish but agreeable tint is obtained by immersing the work previously in a solution of white arsenic in hydrochloric acid, or in a solution of bichloride of platinum, under addition of some vinegar, or rubbing with plumbago. (See also iii. 13.)

Britannia Metal.—

Good: 150 tin, 10 antimony, 3 copper.

Second: 140 tin, 9 antimony, 3 copper.

Casting: (*a*) 210 tin, 12 antimony, 4 copper. (*b*) 100 tin, 5 antimony, 5 hardening. (See below.)

Handles: 140 tin, 5 antimony, 2 copper.

Lamps: 300 tin, 15 antimony, 4 copper.

Registers: 100 tin, 8 antimony, 8 hardening.

Spinning: 100 tin, 4 antimony, 4 hardening.

Spoons: 100 tin, 10 antimony, 5 hardening.

Spouts: 140 tin, 6 antimony, 3 copper.

Hardening: 2 copper, 1 tin.

(See also iii. 24.)

Bronze. *Statuary.*—(*a*) Copper, 88 parts; tin, 9 parts; zinc, 2 parts; lead, 1 part.

(*b*) Copper, 88½ parts; tin, 5 parts; zinc, 10½ parts; lead, 2 parts.

(*c*) Copper, 90 parts; tin, 9 parts; lead, 1 part.

(*d*) Copper, 91 parts; tin, 9 parts.

Medals.—(*a*) Copper, 89 parts; tin, 8 parts; zinc, 3 parts.

(*b*) Copper, 95 parts; tin, 5 parts.

Cutting Instruments.—Copper, 100 parts; tin, 14 parts.

Ornaments.—(*a*) Copper, 82 parts; tin, 3 parts; zinc, 18 parts; and lead, 2 parts.

(*b*) Copper, 83 parts; zinc, 17 parts; tin, 1 part; lead, ½ part.

(See also iii. 17.)

Bullet Metal.—98 lead to 2 arsenic. For round shot the fused metal is dropped from a high elevation in a shot tower into a basin of water; or thrown down a stack of limited height, in which a strong draught of air is produced by a blast machine. (See also iii. 35.)

Chinese Silver.—65·2 parts copper, 19·5 zinc, 13 nickel, 2·5 silver, and 12 cobalt of iron.

Cock Metal.—Copper, 20 lb.; lead, 8 lb.; litharge, 1 oz.; antimony, 3 oz.

Cymbals, Gongs, and Tam-tams.—(*a*) 100 parts of copper with about 25 of tin. To give this compound the sonorous property in the highest degree, the piece should be ignited after it is cast, and then plunged immediately into cold water.

(*b*) 80 parts of copper and 20 of tin, hammered out with frequent annealing.

(*c*) An alloy of 78 of copper and 22 of tin answers better, and can be rolled out.

German Silver.—(*a*) Copper, 50 lb.; zinc, 25 lb.; nickel, 25 lb.

(*b*) Copper, 50 lb.; zinc, 20 lb.; nickel (best pulverised), 10 lb.

(*c*) Copper, 60 lb.; zinc, 20 lb.; nickel, 25 lb. Used for spoons, forks, and table ware.

(*d*) Frick's. 53·39 parts copper, 17·4 nickel, 13 zinc.

(*e*) Copper, 60 lb.; zinc, 20 lb.; nickel, 20 lb.; lead, 3 lb.; iron (that of tin plate being best), 2 lb.

In melting the alloy for German silver, it is difficult to combine a definite proportion of zinc with the compound of nickel and copper previously prepared. In fusing the three metals together there is always a loss of zinc by volatilisation, which may be lessened by placing it beneath the copper in the crucible. The best method is to mix the copper and nickel, both in grains first, place them, thus mixed, in the crucible, when melted add the zinc and a piece of borax the size of a walnut. The zinc will gradually dissolve in the fluid copper, and the heat may be raised as their fluidity increases. In this instance, as in all others of forming alloys, it is profitable to mix the oxides of the various metals together, and reduce them under the protection of a suitable flux. The metal nickel can be produced only from pure oxide of nickel; and, as purity of the alloy is essential to good quality, the common commercial zinc is *not* sufficiently pure for forming argentan. Copper cannot well be used in the form of oxide, but grain copper or wire-scraps will serve equally as well. (See also iii. 20.)

Gold, Artificial—Pure copper, 100 parts; zinc, or preferably tin, 17 parts; magnesia, 6 parts; sal-ammoniac, 3·6 parts; quicklime, 1·8 part; tartar, 9 parts. The copper is first melted; the magnesia, sal-ammoniac, lime, and tartar are then added, separately and by degrees, in the form of powder; the whole is now briskly stirred for about half an hour, so as to mix thoroughly, and then the zinc is added in small grains by throwing it on the surface and stirring till it is entirely fused; the crucible is then covered, and the fusion is maintained for about 35 minutes. The surface is then skimmed and the alloy is ready for casting. It has a fine grain, is malleable, and takes a splendid polish. Does not corrode readily, and for many purposes is an excellent substitute for gold. When tarnished, its brilliancy can be restored by a little acidulated water.

Gun Metal.—Brass, 112 lb.; zinc, 14 lb.; tin, 7 lb. (See also iii. 21.)

Journal Boxes.—Copper, 24 lb.; tin, 24 lb.; and antimony, 8 lb. Melt the copper first, then add the tin, and lastly the antimony. It should be first run into ingots, then melted and cast in the form required for the boxes.

Impressions.—Lead, 3 lb.; tin, 2 lb.; bismuth, 5 lb.

Medals.—50 parts copper, 4 zinc.

Muntz Metal.—6 parts copper; 4 zinc. Can be rolled and worked at a red heat. (See also iii. 29.)

Or-Molu.—The or-molu of the brass-founder, popularly known as an imitation of red gold, is extensively used by French workmen in metals. It is generally found in combination with grate and stove work. It is composed of a greater portion of copper and less zinc than ordinary brass, is cleaned readily by means of acid, and is burnished with facility. To give this material a rich appearance, it is not unfrequently brightened up after "dipping" by means of a scratch brush, the action of which helps to produce a very brilliant gold-like surface. It is protected from tarnish by the application of lacquer.

Pinchbeck.—Copper, 5 lb.; zinc, 1 lb.

Pipe Metal for Organs.—Melt equal parts of tin and lead. This alloy is cast instead of rolled in the desired form of sheets, in order to obtain a crystallised metal, which produces a finer tone. The sheets are formed by casting the metal on a horizontal table, the thickness being regulated by the height of a rib or bridge at one end, over which the superfluous metal flows off. The sheets thus obtained are planed with a carpenter's plane, bent up, and soldered.

Queen's Metal.—A very fine silver-looking metal is composed of 100 lb. of tin, 8 of regulus of antimony, 1 of bismuth, and 4 of copper.

Rivet Metal.—(*a*) Copper, 32 oz.; tin, 2 oz.; zinc, 1 oz.

(*b*) Copper, 64 lb.; tin, 1 lb.

Silver, Imitation.—Tin, 3 oz.; copper, 4 lb.

Speculum Metal.—(*a*) Equal parts of tin and copper form a white metal as hard as steel.

(*b*) Less tin and a small quantity of

arsenic added to the alloy forms a white hard metal of high lustre.

(*c*) 2 lb. copper, 1 lb. tin, 1 oz. arsenic form a good speculum metal.

(*d*) An alloy of 32 copper, 16·5 tin, 4 brass, 1·25 arsenic, is hard, white, and of brilliant lustre. (See also iii. 32.)

Statuary Metal.—(*a*) 91·4 parts copper, 5·53 zinc, 1·7 tin, 1·37 lead.

(*b*) Copper 80, tin 20.

Stereotype Metal.—1 tin; 1 antimony; 4 lead. In using stereotype metal, brush the type with plumbago or a small quantity of oil, then place in a frame, and take a cast with plaster of Paris. The cast is dried in a very hot oven, placed face downwards upon a flat plate of iron; this plate is laid in a tray or pan of iron, having a lid securely fastened, and furnished with a hole at each corner. Dip the tray in the fluid metal, which will flow in at the four corners. When the tray is removed, dip the bottom only in water; and as the metal contracts in cooling, pour in melted metal at the corners so as to keep up the fluid pressure, and obtain a good solid cast. When cool open the tray; remove the cake of plaster and metal, and beat the edges with a mallet to remove superfluous metal. Plane the edges square, turn the back flat, in a lathe, to the required thickness, and remove any defects. If any letters are damaged, cut them out, and solder in separate types instead. Finally, fix upon hard wood to the required height.

Casting Stereo-Plates by the Paper Process.—Lay a sheet of tissue paper upon a perfectly flat surface, and paste a soft piece of printing paper, which must be pressed evenly on, to the tissue. Lay the paper on the form, previously oiled, and cover with a damp rag; beat with a stiff brush the paper in evenly, then paste a piece of blotting paper, and repeat the beating in; after which about three more pieces of soft tenacious paper must be pasted and used in a similar way; back up with a piece of cartridge paper. The whole must then be dried with moderate heat, under a slight pressure. When thoroughly dry, brush well over with plumbago or French chalk. When this is done it is ready for the matrix. This is a box of a certain size for the work required, the interior of which is type high. In it is what is termed a gauge, which lifts out to insert your paper cast, and is regulated by hand to the size of the plate required. This being placed inside, the lid is shut down and screwed tight, with the end or mouth-piece left open. By this orifice the metal is poured in, and, as it is mounted to swing, the box is moved about so as to well throw down the metal and make a solid cast. Then water is dashed on the box, the screw-bar is unshackled, the lid is lifted, the plate is taken off, and the paper cast is again ready for work. (See also iv. 217.)

Tinning.—Malleable iron, 1 lb., heat to whiteness; add 5 oz. regulus of antimony, and 24 lb. tin.

Tombac.—(*a*) Copper, 16 lb.; tin, 1 lb.; zinc, 1 lb.

(*b*) Red. Copper, 10 lb.; zinc, 1 lb.

Tutania.—(*a*) Iron or steel, 8 oz.; antimony, 16 oz.; nitre, 3 oz. Melt and harden 8 oz. tin with 1 oz. of this compound.

(*b*) Antimony, 4 oz.; arsenic, 1 oz. tin, 2 lb.

Type Metal.—9 parts lead to 1 antimony forms common type metal; 7 lead to 1 antimony is used for large and soft type; 6 lead and 1 antimony for large type; 5 lead and 1 antimony for middle type; 4 lead and 1 antimony for small type; and 3 lead to 1 antimony for the smallest kinds of type. (See also iii. 33.)

White Metal.—(*a*) Tin, 82; lead, 18; antimony, 5; zinc, 1; and copper, 4 parts.

(*b*) Hard. Sheet brass, 32 oz.; lead, 2 oz.; tin, 2 oz.; zinc, 1 oz.

AMBER.

Working.—Amber in the rough is first split and cut rudely into the shape required by a leaden wheel worked with emery powder, or by a bow-saw having a wire for the blade, Tripoli or emery powder being used with it. The roughly-formed pieces are then smoothed with a piece of whetstone and water. The polishing is effected by friction with whiting and water, and finally with a little olive oil laid on and well rubbed with a piece of flannel, until the polish is complete. In this process the amber becomes hot and highly electrical; as soon as this happens it must be laid aside to recover itself before the polishing is continued, otherwise the article will be apt to fly into pieces.

Mending.—Smear the parts which are to be united with linseed oil, hold the oiled part carefully over a small charcoal fire, a hot cinder, or a gas-light, being careful to cover up all the rest of the object loosely with paper; when the oiled parts have begun to feel the heat, so as to be sticky, pinch or press them together, and hold them so till nearly cold. Only that part where the edges are to be united must be warmed, and even that with care lest the form or polish of the other parts should be disturbed; the part joined generally requires a little re-polishing.

AQUAFORTIS.

Simple or Single.—Distil 2 lb. of saltpetre and 1 lb. of copperas.

Double.—Saltpetre, 6 lb., copperas, 6 lb. in its usual crystallised state, together with 3 lb. calcined to redness.

Strong.—Copperas calcined to whiteness, and white saltpetre, of each 30 lb.; mix, and distil in an iron pot with an earthenware head.

Spirit of Nitre.—White saltpetre, 6 lb.; oil of vitriol, 1½ lb.; distil into 1½ pint of water.

Dilute.—Strong aquafortis, 1 oz. by measure, and water 9 oz. by measure.

Proof.—The same as Assayer's Acid.

Compound.—Double aquafortis, 16 oz.; common salt, 1 dram: distil to dryness.

AQUA-REGIA.

(*a*) Distil together 16 oz. of spirit of nitre, with 4 oz. of common salt.

(*b*) Equal parts of nitric acid and muriatic acid mixed.

(*c*) Nitric acid 2 parts, and muriatic 1 part.

BLACKING.

Paste.—Mix 1 part of ivory black, ½ treacle, ⅛ sweet oil, then add ¼ oil of vitriol and ⅛ hydrochloric acid. Dilute each ingredient with three times its weight of water before mixing.

Liquid.—(*a*) 2 lb. of ivory black in fine powder, 1½ lb. treacle, ¼ pint of sperm oil. Rub the black and oil well together, add the treacle and mix.

(*b*) 4 oz. of ivory black, 3 oz. coarse sugar, a tablespoonful of sweet oil, and 1 pint of weak beer; mix them gradually together until cold.

BLEACHING.

Ivory.—(*a*) Antique works in ivory that have become discoloured may be brought to a pure whiteness by exposing them to the sun under glasses. It is the particular property of ivory to resist the action of the sun's rays, when it is under glass; but when deprived of this protection, to become covered with a multitude of minute cracks. Many antique pieces of sculpture in ivory may be seen, which, although tolerably white, are, at the same time, defaced by numerous cracks; this defect cannot be remedied; but, in order to conceal it, the dust may be removed by brushing the work with warm water and soap, and afterwards placing it under glass. Antique works in ivory that have become discoloured, may be rubbed with pumice and water, and while yet wet placed under glasses. They should be daily exposed to the action of the sun, and be turned from time to time, that they may become equally bleached; if the brown colour be deeper on one side than the other, that side will, of course, be for the longest time exposed to the sun.

(*b*) Immerse for a short time in water containing a little sulphuric acid, chloride of lime, or chlorine.

(*c*) Expose it in the moist state to the fumes of burning sulphur, largely diluted with air.

(*d*) Ink stains may be removed by repeatedly using a solution of quadroxalate of potash in water. (See also ii. 33.)

Lace.—Lace may be restored to its original whiteness by first ironing it slightly, then folding it and sewing it into a clean linen bag, which is placed for twenty-four hours in pure olive oil. Afterwards the bag is to be boiled in a solution of soap and water for fifteen minutes, then well rinsed in lukewarm water, and finally dipped into water containing a slight proportion of starch. The lace is then to be taken from the bag and stretched on pins to dry. (See also ii. 149.)

Paper. — (*a*) For bleaching rags, and other materials from which paper is at first fabricated, rags, when grey or coloured, are to be separated and ground in the paper-mill in the usual way, till brought to a sort of uniform consistence, having been previously macerated according to their quantity and tenacity. The mass is then treated with an alkaline lye. It is next treated with a solution of chloride of lime. If this immersion do not produce the desired effect, which does not often happen if the colours are tenacious, such as red and blue, let the treatment with the alkaline lye be repeated, and follow it with another bath of the chlorine preparation. Then sour the whole in a bath of sulphuric acid, much diluted and cold, for when hot its action will be less effectual. Water is then to be run upon it till it comes off without colour or indication of acidity. Black is the most easily discharged colour, and will seldom require being treated with lye or steep of sulphuric acid, one bath of alkali and another of chloride of lime being sufficient to produce a good white.

(*b*) *Old printed* or *written paper* is first sorted according to its quality, and all the yellow edges cut off with a bookbinder's plane. One hundredweight of this paper is put sheet by sheet into vats sufficiently capacious, with 500 quarts of hot water. The whole is stirred for about an hour, and as much water gradually added as will rise about three inches above the paper, and left to macerate for four or five hours. It is then ground coarsely in the mill, and boiled in water for about an hour, taking care to add before it begins to boil, 13 quarts of caustic alkaline lye. After boiling, it is macerated in the lye for 12 hours, when it is pressed, and, if sufficiently white, made into paper.

(*c*) Paper which has been very imperfectly bleached may be rendered thoroughly white by pouring upon it in succession, as dilute solutions, 3½ parts alum, 1 part chloride of barium, a little free hydrochloric acid, and $\frac{1}{8}$ part calcined chalk—stiring well during the operation. The fibres of the paper become firmly coated with the brilliant white sulphate of baryta which is formed. (See also ii. 35.)

Prints and Printed Books.—Simple immersion in oxygenated muriatic acid, letting the article remain in it, a longer or shorter space of time, according to the strength of the liquor, will be sufficient to whiten an engraving. If it be required to whiten the paper of a bound book, as it is necessary that all the leaves should be moistened by the acid, care must be taken to open the book well, and to make the boards rest on the edge of the vessel, in such a manner that the paper alone shall be dipped in the liquid; the leaves must be separated from each other in order that they may be equally moistened on both sides. The liquid assumes a yellow tint, and the paper becomes white in the same proportion; at the end of two or three hours the book may be taken from the acid liquor, and plunged into pure water with the same care and precaution as recommended in regard to the acid liquor, that the water may touch both sides of each leaf. The water must be renewed every hour, to extract the acid remaining in the paper, and to dissipate the disagreeable smell. Printed paper may also be bleached by sulphuric acid, or by alkaline or soap lyes. (See also ii. 115.)

Silk.—A lye of white soap is made by boiling in water 30 lb. of soap for every 100 lb. of silk intended to be bleached, and in this the silk is steeped till the gum in the silk is dissolved and separated. The silk is then put into bags of coarse cloth and boiled in a similar lye for an hour. By these processes it loses 25 per cent. of its original weight. The silk is then thoroughly washed and steeped in a hot lye composed of 1½ lb. of soap, 90 gallons of water, with a small quantity of litmus and indigo diffused. After this, it is carried to the sulphuring room; 2 lb. of sulphur are sufficient for 100 lb. of silk. When these processes are not sufficiently successful, it is washed with clear *hard* water and sulphured again. (See also ii. 38.)

Wool.—The wool is first prepared according to the purposes for which it is intended, by treating it with solutions of soap. By this process it is cleared of a great quantity of loose impurity and grease which is always found in wool, often losing no less than 70 per cent. of its weight. The heat of the lye must be carefully attended to, as a high temperature is found to fix the unctuous matter or yolk of the wool. After washing it is taken to a sulphur chamber, where it is exposed to the fumes arising from the slow combustion of sulphur, for from five to twenty hours, according to circumstances. It is again washed, and then immersed in a bath composed of pure whiting and blue. It is then exposed a second time to the fumes of the sulphur, and washed with a solution of soap, which renders it of the proper whiteness. (See also articles on Bleaching in Spons' Encyclopædia.)

BOILER INCRUSTATIONS.

The following remedies have been used with varying success to prevent incrustation:—

1. Potatoes, $\frac{1}{50}$th of weight of water prevents adherence of scale.

2. 12 parts salt, 2½ caustic soda, ⅛ extract of oak bark, ½ potash.

3. Pieces of oak-wood suspended in boiler and renewed monthly.

4. 2 oz. muriate of ammonia in boiler twice a week.

5. A coating 3 parts of black-lead, 18 tallow, applied hot to the inside of the boiler every few weeks.

6. 12½ lb. of molasses fed into an 8-horse boiler at intervals, prevented incrustation for six months.

7. Mahogany or oak sawdust in small quantities. Use this with caution, as the tannic acid attacks iron.

8. Carbonate of soda.

9. Slippery elm bark.

10. Chloride of tin.

11. Spent tanners' bark.

12. Frequent blowing off.

13. Method adopted by Schübler. It is liquid carbonic acid, which he brings in a bomb in connection with the boiler, which, though cold, is still filled with water. The water hereby becomes saturated with carbonic acid. This carbonated water then dissolves the carbonate of lime, the principal part of the incrustation, and forms an acetous carbonate of lime, which falls off, and, after removal of the water, the boiler will be found free from the incrustation. (See also ii. 42.)

BOOKBINDING.

Tools.—To bind a book well, certain tools are indispensable; but very few will go a good way; and a book may be put together very decently with the aid of no other tools than a shoemaker's hammer and a glue-pot, with the addition of such implements as are usually to be met with in every household. The necessary tools for small work are: a sewing press; a cutting press, the small music-paper size; half-a-dozen pressing boards, as large as the press will admit, and as many of octavo size; as many cutting and backing boards; a bookbinder's hammer, folder, knife, small shears, saw, paste-bowl, a quire or two of demy or royal printing paper, a quire or two of marbled paper, and some leather and coloured cloths for covers.

Pressing.—As it is desirable that the book should be as thin as possible, and not have a swollen appearance when finished, the sheets ought first to be compressed. The binder does this by beating the volume in sections with a 14-lb. hammer, or passing it between the rollers of a rolling machine. Instead of that we may divide the volume in half-a-dozen sections, and placing one of the pressing boards on each, screw them all together in the press as tight as possible, and leave them there for a night. After being pressed, the sections are taken from the boards; the book is then held between the extended fingers of each hand, and the back and head are knocked up square and even; one side of the book is then laid upon a pressing board, beyond which the back must project ½ inch or so; a second pressing board of the same size is placed on the upper side, parallel with the first, and the boards being firmly grasped with the left hand, the book is lowered into the cutting press, which is screwed up tight, and three cuts, not quite $\frac{1}{16}$ inch in depth, are made with a saw in the back—one in the middle, and one at about 2½ in. distant on each side of it; two additional cuts are then made outside of the three, and distant about 1½ in. from them. These measurements would, of course, be different for a volume of different size, but the proportions will do for any volume.

Sewing.—The book is now taken to the sewing press, where the binder suspends three cords from the top rail, which are fastened underneath by means of brass keys; the cords may be shifted to any position, and being made to correspond with the three central cuts in the back of the book, they are tightened and kept in their place by means of the nuts and screws on the side pillars. The sewing is performed in the following manner:—First, a fly-leaf or end paper is laid on the press, and sewn to the cords by passing the needle into the first right-hand cut, or catch-stitch mark, with the right hand; the left hand, which is inserted in the middle of the section, receiving the needle and returning it outwards on the head side of the cord, where it is taken by the right hand, and passed through again on the other side of the cord; thus with all three of the cords, until the needle is brought out at the last left-hand cord or catch-stitch groove, care being taken that the needle never penetrates the cord or twine. The thread is now drawn to the left gently, until only 2 inches or so are left undrawn, at the point where the needle first entered. The first sheet is then laid on, the title-page downwards, and sewn on in the same way, as the needle returns towards the head of the book; when the needle comes out at the catch-stitch mark over the end of thread left undrawn, the sewing thread is tied to that end in a firm knot. Thus all the sheets are sewn in succession, care being taken, on arriving at the catch-stitch, to fasten each sheet to its predecessor by passing the needle round the connecting thread. After he has sewn 4 or 5 sheets, the binder will find his thread exhausted, when he must join on a new length with such a knot as will not be likely to come undone. Several volumes may be sewn on one set of cords, but some attention is necessary that they be not sewn together, and that the cords be long enough for the subsequent purposes.

Cutting.—After sewing, the book is cut from the press, with about 2 inches of the cords protruding on each side. The back should now receive a coat of glue, and when that is dry, the ends of the cords are untwisted and scraped with a blunt knife till the fibres of the tow are well separated. Now is the time to insert ornamental end-papers, if any are desired; these may be either of marbled or coloured papers; the sheet is folded with the plain side outwards, one-half of it being pasted; it is then laid between the fly-leaves, with the fold of which it is closely worked; the other half is then pasted, and the outside fly-leaf is rubbed down upon it. The back of the book has to be rounded, which is done by laying the volume with the fore-edge towards the operator, who, pressing the fingers of his left hand upon it, gently taps the back up and down with a hammer, changing the sides alternately until the back is beaten into a somewhat circular shape. The book is then placed between two backing boards, the thick edges of which are ranged parallel with each other, within about $\frac{1}{8}$ inch of the back. The boards and book, being tightly grasped with the left hand, are lowered into the cutting press, until the boards are flush with the cheek of the press, which is then screwed as tightly as possible. The back is hammered gently and uniformly up and down each side, and a little in the middle, which causes it to spread over the boards so as to form the required projection. The book, thus backed, is ready for the covers, which are of millboard, and, being cut to the required size, either with shears or in the cutting press, are pierced with holes pricked with a bodkin, two at each cord, one about $\frac{1}{2}$ inch from the edge, and the second as much beyond it. The frayed cords are then sodden with paste, drawn through the outer side of the board or cover, and passed through the other hole to the outer side again. The book is then held in the left hand, while, with the right, the pasted cords are hammered on a smooth piece of iron (a flat iron screwed into the press will do) into the substance of the millboard covers. It should now be left to dry. The next step is that of cutting the edges, which is rather a difficult process. Hold the book in the left hand, with the fore-edge upwards, and allow the covers to hang down on each side; thrust a paper knife or a flat piece of metal between them and the back of the book. Then placing a cutting board on each side, and opening the covers horizontally, beat the back of the book against the press until it is perfectly flattened. A wedge-shaped cutting board is then placed on the left-hand side of the book, so as to stand with its thick edge considerably higher than the course the knife will take; another board is then placed on the right side, exactly on the line which the knife is to follow, and which line must be previously marked with the point of a pair of compasses, and so measured that the edge when ploughed may fall about $\frac{1}{6}$ inch within the projection of the covers. When the boards are thus placed, the paper knife or flat piece of metal is withdrawn, the covers are allowed to hang down, and the volume is thus carefully lowered into the cutting press, until the right-hand board is flush with the cheek, when the press must be screwed tight. The cutting press stands on a hollow frame some 3 feet in depth, which allows of large books being partially lowered into it, and also receives the paper shavings as they are ploughed off. It consists of two wooden cheeks connected by two sliding bars, and two wooden screws. Upon one of the cheeks are two guides, or small raised rails, for the plough to work in. The cutting instrument consists of two sides, connected by a screw with a handle, and by two slide bars. A knife is fastened to the under side of cheek by a strong bolt, which perforates the cheek perpendicularly, and also the circumference of the lateral screw, and is kept tightly in its place by screwing down its nut. The knife is worked by grasping both ends of the lateral screw, moving the plough backwards and forwards, and gradually turning the screw with the right hand, until the whole of the fore-edge is cut through. The book is now taken out of the press, the covers are folded in their place, and the back is rounded as before, when the front edge, if the cutting is well done, will be elegantly concave, corresponding with the convexity of the back. The boards, being kept in the ledge or projection produced by backing, are now pulled down about $\frac{1}{8}$ inch from their central position, and the head is ploughed by the knife in the same way as the fore-edge. Before ploughing the opposite end, the boards are pulled below the head as much again as it is intended they shall project; and this end also being ploughed, it will be seen that the projection of the covers is equal on the three sides, or, better still, that it is a little in excess on the fore-edge.

Ornamenting. — After cutting the edges of a book, the next process is to ornament them. This may be done in a simple way by sprinkling them with a brush dipped in a thin solution of umber, or any other colour, ground fine and mixed with size. A more elaborate method is that of marbling the edges, for which purpose a trough must be provided of convenient size and depth, which is filled with pure gum water. Coloured pigments, spirit-ground and mixed with a little ox-gall, are then dripped on the surface of the fluid from a bunch of quills dipped in them — such colours being used as will float and not sink to the bottom. These are then combed with a coarse comb into a neat pattern, and the book being tied between two boards, the edges are applied to the floating colours, which are thus transferred to them. A dash of cold water over them fixes the colours and heightens their brilliancy.

Head-banding.—There are two kinds, stuck on and worked. Head-bands stuck on are formed by cutting a piece of striped linen about an inch deep and as wide as the thickness of the book, folding it over a piece of twine, and gluing it to the back so that the enclosed twine shall in a manner lap over the cut edge, the same being repeated at the opposite end. In well-bound books, however, the head-bands are worked on in the following way:—A strip of string, prepared by rolling it tight in pasted paper, is chosen of a size suited to that of the book; stout silk thread of one or two colours is then taken; if two colours are used, they are doubled and tied together by the ends, one of them being previously threaded in a needle. The book is placed in the cutting press with the back uppermost, the head being elevated towards the workman; the needle is passed through the middle of the second section, on the left-hand side, just below the catch-stitch, and drawn out far enough to bring the knot joining the two silks close into the middle of the section; the needle is then brought up, and passed again through the same place, and the silk is drawn nearly close; the round strip is placed in the loop thus formed, and the silk is drawn tight with the left hand; the other silk is brought over with the right, and passed under and over the head-band, and held tight with the left hand; the other silk is now put over that, and also under and over the head-band; they are thus worked alternately over each other for about ten sheets or sections; the needle is then passed below the catch-stitch to keep the head-band in its place, and brought over it again, and the work is proceeded with as before. This weaving and frequent fastening to the catch-stitch goes on as far as the last sheet but one, when the needle is passed through the section and over the head-band twice, and fastened to the back. The ends of the head-band are then cut off, almost close to the silk at each end. The braiding produced by working one silk over the other should rest evenly on the leaves of the book. Both ends of the book being worked in this way, the glue-brush is drawn across the back of the bands, which retains them in their proper places. After head-banding, the book should receive a hollow back, which is formed by cutting a slip of cartridge-paper twice the width of the back and the same length; fold the paper in half, glue the back, and stick on one of the folded sides, leaving the other doubled upon it.

Casing.—The volume is now ready for covering with leather, cloth, or leather and paper. For whole-bound volumes the leather is cut nearly an inch larger all round than the open book, and the edges are pared thin with a sharp knife. The inner side of the leather is now well soaked with strong paste, and a small slice being cut from the corners of the covers where they touch the back, the volume is laid on the pasted leather, care being taken that the covers are in the right position, and the two sides are first covered smoothly but not too tightly. The folding over of the pasted leather inside the covers and outside the back, so as to give a handsome appearance to the ends of the volume, is a matter of some difficulty, which, however, a little practice will overcome. It should be done so that the leather in a manner embraces the head-band, which lies half-concealed within it, and yet does not project beyond the proper projection of the covers.

After the ends are finished, which operation will be materially assisted by a paper knife having one pointed end, the corners must be attended to; the superfluous leather meeting at the angle must be cut off, the head and foot must be first smoothed down, and then the fore-edge portion folded over them. This requires to be done carefully to look well, and before doing it the binder must see that the covers are lifted over the projecting ledges of the back into the position they ought to occupy. While the leather is soft and moist with the paste, anything may be done with it, and by the help of the folder it may be moulded so as to form a good-looking head. The leather should be pressed in at the corners where the small pieces were taken off the boards, and the folder passed once or twice up and down the hinges of the cover to ensure their opening easily. Lastly, a piece of thread may be tied round the indented corners of the back from end to end, and the whole left to dry.

For half-bound books, which are more easily managed, the back and covers are put on separately, the leather being pared in the same way, and small waste bits being used for the corners. When a volume has dried after covering, the ends must be pasted down, and it should remain a little time in the press.

Finishing.—For this purpose provide a book or two of gold leaf, a plain single bookbinder's fillet, a few alphabets of capital letters, a gold-cushion, which can be made by stretching a piece of calf leather rough side upwards over a pad of wadding on a board 10 inches by 8, and some other small items, the use of which will presently appear. First wash the cover with clear paste water, water in which a little paste is dissolved. Such parts as are to be gilded must then be coated twice with glaire or albumen, which is the white of eggs first whipped into froth, and then suffered to subside into a clear liquid. Do not glaire the leather all over, but apply it with a camel-hair pencil and ruler only on the parts where the fillet of gold is to appear. To gild, spread a leaf of gold on the cushion with a knife and blow it flat, then cut it into strips about $\frac{1}{6}$ inch wide. Heat the fillet at the fire until it is just hot enough to fizz under the wet finger; if it sputters it is too hot, and will burn the leather; touch its edge with a rag slightly moistened with sweet oil, and with the same rag rub over the part of the book to be gilt. Roll the fillet softly on the strips of gold, which will adhere to it; when enough is taken up, roll it with a heavier pressure along the glaired lines, and the gold will be indelibly transferred to the leather, what is superfluous being easily wiped away with a soft rag. When the sides of the book are being filleted it may lie on clean paper on the cheeks of the press, or on a pressing board; but when the back is being done it must be screwed in the press in a horizontal position, the back projecting an inch or two.

Substitute for Brass Lettering.—Place an open vessel half-full of water on the fire, and let it boil, and set a small empty tin pot floating within it, loading the pot with some weight that it may sink low in the water. Obtain some ordinary printing types and arrange them in the required order as a compositor would, in one of those brass frames with wooden handles used for marking linen, and screw them tight in their place, taking care to have them all level with each other on the face. Lay the face of the types in the tin pot, in which some simple contrivance should be placed to prevent their being damaged, and let them get as hot as they will, as in this situation they cannot get too hot. Cut a piece of real morocco leather larger than the size of the label wanted, breathe on it, and give it one coat of glaire ; when the glaire is dry rub it slightly over with the oil-rag, and lay on the centre enough leaf gold to receive the impression of the types; place the label on a rather hard pad, and stamp the types on the gold with a sharp even pressure.

On wiping off the gold with the rag, the impression of the type remains clear and full, and if well done is far more close and distinct than anything which can be done by the most expert finisher with the brass letters of the bookbinder. The label is now cut to the proper size, and pasted evenly in its place on the back of the volume ; to look well, it should be pared round the edges with a sharp knife until the extreme edge is as thin as paper. After it is dry, a gold fillet may be passed over the juncture of morocco with the calf or other leather by way of finish. The above is the easiest mode of lettering for the amateur, but it is practicable only on real morocco, the heat which can be imparted to printers' metal by hot water not being sufficient to burn the gold into ordinary leather; it is, however, a permanent method.

Polishing Edges of Leaves.— Screw the book tight in the press between pressing boards, and rub them briskly with an agate or a dog's tooth. It is important that the press should be tightly screwed, otherwise the leaves will cling together when the operation is over.

Binding without Tools.—(*a*) All that need be provided is a little melted glue, some paste, a needle and stout thread, some white and some coloured papers, and a few other trifling items. Arrange the sheets to be bound in their proper order, and beat them even at the back and head ; subject them to a heavy pressure between two flat surfaces, by piling weights upon them. If there is a press handy, press them in that, so as to make them lie as close as possible. Now take two pieces of tape ½ inch wide, and each 2 inches longer than the width of the back of the book. Stiffen the tape by drawing it through paste, and let it dry, with as little of the paste adhering to it as possible, before using. Fold the pieces of stiff tape, and place the sheets within them in such a position that the two tapes will divide the length of the back into three equal parts, or thereabouts. With a lead pencil, while the sheets are pressed down firmly with the left hand, draw a line down each side of the tapes, and two other lines, each one dividing that part of the back outside the tapes into equal portions. These lines mark the place for the entrance of the needle. The sheets of the book are to be sewn on to the tapes in the same way as directed where the book is sewn on to the cords; but with tapes it is not quite so easy, as during the sewing of the first two or three sheets there is some difficulty in keeping the tapes in their places ; and as there are no cuts or grooves made with the saw, some force is required to get the needle through the paper. When the book is sewn, the threads fastening each sheet are seen outside the tapes. The back must now receive a coating of glue, not too thin, after which it may be left to dry. The glue being hard and set, the book may be cut on the edges, with a straight-edge and a sharp knife. With a thin volume this is easy enough, but with anything approaching an inch in thickness it will be better to clip any projecting leaves with the shears, and to be content with uncut edges, if a cutting press is not available. The back must next be rounded with the hammer, which may be helped by pulling gently at the tapes while tapping with the tool.

For the covers use the thinnest millboard, or stout pasteboard not thicker than a shilling. Cut two pieces of this of the proper size, so that they shall project about ⅛ inch over the head, foot, and fore-edge of the book, and glue them in their proper position on the projecting tapes, which will adhere to their inner sides. Over the tapes glue strips of coarse canvas an inch wide by six in length, and now glue on the open back in the manner previously directed. When this glue is dry, the volume may be covered with paper, cloth, leather, or vellum. If vellum is used, that must be lined first with clean white paper firmly pasted on it. A cheap covering is dark roan leather; a still cheaper is coloured canvas; but preferable to that are the leather papers sold by stationers. The mode of pasting on the covers has been already described; but if cloth coverings are used, glue and not paste will be necessary to make them adhere.

(*b*) Instead of gluing the tapes to the boards, cut a cloth cover large enough to allow for overlapping, and, allowing for the width of the back, glue the covers on the cloth parallel with each other, and turn in the cloth round the edges. When this is dry, the book may be placed in the cloth cover, the tapes glued to the inner sides, the open back to the back of cloth, the strengthening canvas also being glued over the tapes; and finally, the end-papers being pasted down, the volume is finished. It will look but a homely affair; but it will cost little beyond the trouble, and will effectually preserve the volume. For many volumes published in numbers, the publishers supply covers at the end of the year: these may be securely fastened on by this simple method.

MARBLING PAPER AND BOOK EDGES.—*Wooden Trough.*—This is made of inch deal, about 1⅝ in. in depth and ½ in. in length and breadth larger than the sheets of paper that are to be marbled. This proportion between the size of the trough and paper should always be observed, to prevent waste of colour; of course, troughs of various sizes will be required, where paper of various sizes is to be marbled. The trough must be water-tight, and the edges of the sides of it must be sloped or bevelled off on the outside to prevent any drops of colour which may fall on them from running into the trough and sullying its contents.

A Skimmer, or clearing stick, must be provided for each trough; this is a piece of wood, 2½ in. wide, ½ in. thick, and as long as the trough it belongs to is wide inside; the use of this will be explained hereafter.

A Stone and Muller of marble, or some other hard stone, the size according to the quantity of colour required to be ground. Also a flexible knife, for gathering the colour together.

A dozen or two of small glazed *pipkins* to hold colours in. The pots being furnished with

Brushes made as follows:—Take a round stick about as thick as your finger, and cut a notch all round one end of it; next, take some bristles, 4 or 5 in. long, and place them evenly round the stick, at the notched end, letting them project 1⅝ in. beyond the wood; fasten the bristles to the stick by several turns of stout thread; cut away the ragged bristles, and tie up the brush firmly with fine cord. The use of the notch round the end of the handle is to make the bristles spread out when firmly tied up, so that when used the colour may be scattered about more abundantly.

Rods for drying the paper on when marbled; they should be round, at least on the upper side, and about 1¼ in. in breadth and thickness. Twelve rods 11 ft. long will hang 3½ quires of demy, or 4½ quires of foolscap.

Colours.—Red—vermilion, drop-lake, rose-pink, Venetian red, red ochre. Blue—indigo blue, Prussian blue, verditer. Orange—orange lead, orange orpiment. Black—ivory, blue black. Yellow—Dutch pink, yellow ochre, king's yellow, English pink. The finer the colours are ground, the better and the cheaper will the work be. First the colours should be finely pounded, then mixed with water to the consistence of paste, and put in a colour pot with the knife. From the pot, the colour must be taken out a little at a time, and levigated very fine with pure water.

Compound Colours are made by mixing the colours above mentioned in certain proportions. To make a red colour, mix 3 parts of rose-pink with 1 of vermilion. A finer red—4 parts of rose-pink, 2 parts of vermilion, and 1 part of drop-lake; for very fine work use drop-lake alone, but use it very sparingly, for it is a dear article. Yellow—2 parts of Dutch pink, and 1 part each of king's yellow and English pink. Green—made by mixing blue and yellow. Dark blue—indigo, which may be made lighter by the addition of verditer. Orange brown—2 parts of Venetian red, and 1 part of orange lead. A fine orange—put some fine yellow ochre in a ladle over a fire, and keep it there till it assumes a dark-red colour. Take of this red ochre, finely pounded, and of Venetian red, equal quantities, and add a little orange orpiment or rose-pink; mix all well together. Umber colour—equal quantities of Venetian red, orange lead, and ivory black; this can be lightened with orange lead, or darkened with ivory black. Cinnamon colour—Venetian red with a little Prussian blue. All other colours which may be wanted can be made by mixing together those already described. In addition to the articles already mentioned, obtain a bottle of ox-gall, a bottle of good oil of turpentine, some pure water. The trough must be filled to within $\frac{1}{8}$ inch of the top, with a solution of gum tragacanth, which is prepared as follows: Gum of a pale white semi-transparent appearance is to be soaked in water for at least 48 hours, in the proportion of $\frac{1}{2}$ lb. to $1\frac{1}{2}$ gallon. Pass the solution of gum through a hair sieve or linen cloth, and pour it into the trough. In all cases, when the trough is to be used, the solution should be well stirred up with a few quills, and the surface of it cleared from film by the skimmer above described.

Colours intended to represent Veins are made by adding a small quantity of gall to the various colours, and stirring each well up with a brush, in order that they may be properly mixed. Previous to use, these mixtures of colour and gall are thinned with water to the consistence of cream, and well stirred up.

Colours for producing Spots like Lace-work.—Take some dark blue, or other colour, add some gall to it, and about as much, or a little less, oil of turpentine; stir all well together, and dilute with water. To try the colours, throw on the solution, by shaking the various colour brushes over it, some spots of colour. If the spots spread out larger than a crown-piece in size, the colours have too much gall; if the spots, after spreading out a little, contract again, there is too little gall in them. In the one case more colour must be added, in the other more gall. If the colours are in good order, and paper is to be marbled, the whole surface of the solution in the trough must be covered by colours, in spots, streaks, or whirls, according to the pattern required, and laid on according to directions which will be given presently. The paper should be previously prepared for receiving the colours, by dipping it overnight in water, and laying the sheets on each other with a weight over them. The sheet of paper must be held by two corners, and laid in the most gentle and even manner on the solution covered with the colours, and there softly pressed with the hand that it may bear everything on the solution, taking care not to let the colours flow on to the back of the paper any more than can be avoided: after which it must be raised and taken off with the same care, and then hung to dry over the rods.

Patterns.—(*a*) Throw on red till the solution is nearly covered, then some yellow, black, and green; add, if desired, a little purple with plenty of gall and water in it; twist the colours into any shape by means of a quill.

(*b*) Throw on red, yellow, black, and green, as before: but, for a last colour, add some of the dark blue mixed with turpentine.

(*c*) Throw on red, yellow, black, and green, in the desired proportion; then with a quill draw lines through the colours; after which throw on a greater or less quantity of blue, green, pink, or purple, much diluted, and containing plenty of gall and turpentine.

(*d*) Throw on very fine red for veins;

then plenty of the turpentine blue. If the colours are good, this produces a handsome pattern in a short time.

(*e*) Throw on some dark blue mixed with turpentine, and take this up with a paper previously stained of a yellow, light blue, red, pink, or green colour. To obtain a good green for this purpose, boil French berries in water, add a little spirit or liquid blue, and carefully brush over the paper, which must be good and well sized, with this mixture.

When the colours become too thick for use, add fresh ground colour with water and a little gall to them, and stir them up well. Be particular in getting good turpentine. When the solution of gum gets dirtied, throw it away and make a fresh one. The neatest and most convenient method of marbling the edges of books is to dip one volume at a time, doing the ends first, and throwing back the boards to do the fore-edge; observing to hold the book tight with both hands, and not to dip deeper than the surface, to prevent the solution from spoiling the book. It is the safest way to tie the book between boards before dipping; and, for the sake of convenience and economy, when only a few books are to be marbled, a small trough should be used.

Marbled paper is glazed by a machine similar to that with which cottons are glazed. But a machine of this kind would only be required by those who marble very largely. Book edges are polished by the agate burnisher, and so might small pieces of paper be polished, which were required for any particular purpose. Good common pressing, or hot-pressing, might serve as well as glazing. For any fancy work it would have a fine effect to varnish the marble paper after it had been put to its destined purpose and had become dry. Paste and all moisture chase all the glaze away. The application of a coat of varnish subsequent to the application of paste would double the beauty of the best marble paper, and much improve the common kind, at a trifling expense.

Sprinkling Edges of Books.—Take an old toothbrush and dip it into a coloured ink; shake off the superfluous ink, that the sparks formed may not be too large, and draw an old comb through it in such a manner as to make the ink fly off in sparks over the edges of the book. The following are a few coloured inks:—Red; ¼ lb. of the best logwood is boiled with 1 oz. of pounded alum, and the same quantity of cream of tartar, with half the quantity of water, and, while the preparation is still warm, 1 oz. sugar and 1 oz. gum arabic are dissolved in it. Blue; solution of indigo with pieces of alumina, and mixed with gum, forms a blue ink. Green; this is obtained from verdigris, distilled with vinegar, and mixed with a little gum. Yellow; saffron, alum, and gum water form a yellow. (See also iv. 228.)

BRONZING.

Brasswork.—(*a*) Take lampblack, about a thimbleful, and put it on a flat stone or smooth slate; add four or five spots of gold size, and well mix with a palette knife, making the whole about as thick as putty; well mix. The less gold size there is the better, so that the lampblack just sticks together; if too much gold size be added, the effect will be a bright black and not a dead black. Now add turpentine, about twice its own volume, to the whole, mix with a camel-hair brush, and apply to the brasswork.

(*b*) Dip the article bright in aquafortis; rinse the acid off with clean water, and place it in the following mixture until it turns black:—Hydrochloric acid, 12 lb.; sulphate of iron, 1 lb.; and pure white arsenic, 1 lb. Then take out, rinse in clean water, dry in sawdust, polish with black-lead, and then lacquer with green lacquer.

(*c*) 1 part oxide of iron, 1 part white arsenic, 12 parts hydrochloric acid. Clean the brass well to get rid of lacquer or grease, and apply with a brush until the desired colour is obtained. Stop the process by oiling well, when it may be varnished or clear lacquered.

Copper Utensils. — (*a*) If the article is not new take it to pieces, wiping off all the solder with a wisp of tow, and taking care not to let any of the metal in the fire; then twist a little tow on the end of a stick, and pickle with spirits of salts all those parts that are tinned, pickling the outside as well as the in, rinse in water, and scour outside with wisp of tow and sand; fine coke-dust is best for the tinned parts, which must be brought quite clean, rinse clean, smear the outside with wet whiting, and then tin with bar tin, sal ammoniac being the best agent; then pickle only the outside with diluted spirits of salts, rinse, and scour with clean sand till the surface is perfectly clean and bright, taking care to rub as much as possible in one direction. The cast parts and those not tinned are pickled in dilute oil of vitriol, and scoured with sand, same as the body; beat with a brush, then dry in saw-dust, and the article is now ready for bronzing. Procure some crocus: some knowledge is wanted to select a good one, as it may be too light, or too dark, or too fine, or too coarse; then make into a thick cream with water. Having used a forge fire to tin with, to be on the safe side it is best to rake out all the old coke and light afresh, and the coke should be a nice, clear, firm, grey one, in pieces the size of a walnut; also have some clear bright coal, then blow up a clear bright fire, and heap up plenty of coke that the sulphur may burn off; now take a little of the mixed crocus and brush up the body, using a hard brush; get all the crocus off clean, and wipe with a clean piece of rag, and it is best to hold with this, as the perspiration of the hand will prevent the colour taking; now blow up fire, making a hole in centre, so that a good blast comes up, and having painted the body evenly with the red cream, so that the colour does not run (a flat camel-hair brush, 2½ in. wide, is the best thing to do it with), hold it with the tongs and turn it steadily so that all parts are exposed fairly to the blast. As soon as it is dry, throw into the fire a bit of coal about the size of a Spanish nut, more or less to size of work, and let the work have an even coat of smoke till it is quite black, but no more (if the coal is not burnt out hold the work on one side), then turning it steadily, keep up a sharp blast till the smoke is burnt off, and stand it to cool. Treat cast parts the same, but as soon as the smoke is burnt off, dip them into clean cold water, else, on account of their thickness the colour will burn; when cold, wipe the crocus off the body with a wisp of clean tow, then brush hard till quite clean, wipe with rag, and repeat the above once or twice, according to the shade required. To finish properly the body is hammered all over with bright hammers shaped to parts, and on suitable tools which are covered with two or three folds of lasting; the inside is scoured bright, and the parts are soldered together, using rosin.

(*b*) Dissolve in vinegar two parts verdigris and one part sal ammoniac. Boil, skim, and dilute with water, until white precipitate ceases to fall. Set in a pan meanwhile the articles to be bronzed, made perfectly clean and free from grease. Boil solution briskly, and pour over the articles in the pan and boil them briskly. A bright reddish-brown colour is thus acquired; but the articles should be frequently inspected, and removed as quickly as the desired shade is obtained. Then they are to be repeatedly washed and dried. The solution must not be too strong, for then the bronze will come off by friction, or turn green on exposure to the air.

(*c*) Dissolve 2 oz. of nitrate of iron, and 2 oz. of hyposulphite of soda in 1 pint of water. Immerse the articles in the bronze till of the required tint, as almost any shade from brown to red can be obtained; then well wash with water, dry, and brush. One part of perchloride of iron and two parts of water mixed together, and the article immersed in the liquid, gives a pale or deep olive green, according to the time of immersion. If nitric acid is saturated with copper, and the article dipped in the liquid, and then heated, it assumes a dark green. If well brushed, it may be lacquered with pale gold lacquer, or else polished with oil.

Electrotypes. *Green.*—Steep the medal or figure in a strong solution of common salt or sugar, or sal ammoniac, for a few days, wash in water and allow to dry slowly, or suspend over a vessel containing a small quantity of bleaching powder, and cover over—the length of time it is allowed to remain will determine the depth of the colour.

Brown.—Four or five drops of nitric acid to a wine-glassful of water, and allowed to dry, and when dry impart to the object a gradual and equal heat; the surface will be darkened in proportion to the heat applied.

Black. — Wash the surface of the object over with a little sulphide of ammonium (dilute), and dry at a gentle heat; polish with a hard brush afterwards.

Gas Fittings.—(*a*) Boil the work in strong lye, and scour it free from all grease or old lacquer; pickle it in diluted nitric acid till it is quite clean (not bright), then dip in strong acid, and rinse through four or five waters; repeat the dip, if necessary, till it is bright; next bind it very loose with some thin iron wire, and lay it in the strongest of the waters you have used for rinsing. This will deposit a coat of copper all over it if the water or pickle be not too strong; if such is the case the copper will only be deposited just round where the wire touches. When the copper is of sufficient thickness wash it again through the waters, and dry it with a brush in some hot saw-dust; box-dust is best, but if this not at hand, oak, ash, or beech will do. It is now ready for bronzing. The bronze is a mixture of black-lead and red bronze, varied according to shade required, mixed with boiling water. The work is to be painted over with this and dried, then brushed until it polishes. If there are any black spots or rings on the work, another coat of the bronze will remove them. Lacquer the work with pale lacquer, or but very slightly coloured, for if it is too deep it will soon chip off.

(*b*) Another method is to mix vinegar or dilute sulphuric acid (1 acid 12 water) with powdered black-lead in a saucer or open vessel; apply this to the brass with a soft plate brush by gently brushing. This will soon assume a polish, and is fit for lacquering. The brass must be made slightly warmer than for lacquering only. A little practice will enable the operator to bronze and lacquer with once heating. The colour, black or green, varies with the thickness of black-lead.

Iron.—To one pint of methylated finish add 4 oz. of gum shellac and ½ oz. gum benzoin; put the bottle in a warm place, shaking it occasionally. When the gum is dissolved, let it stand in a cool place two or three days to settle, then gently pour off the clear into another bottle, cork it well, and keep it for finest work. The sediment left in the first bottle, by adding a sufficient quantity of spirit to make it workable, will do for the first coat or coarser work when strained through a fine cloth. Next get ½ lb. of finely-ground bronze green, the shade may be varied by using a little lampblack, red ochre, or yellow ochre; let the iron be clean and smooth, then take as much varnish as may be required, and add to the green colour in sufficient quantity; slightly warm the article to be bronzed, and with a soft brush lay a thick coat on it. When that is dry, if necessary lay another coat on, and repeat until well covered. Take a small quantity of the varnish and touch the prominent parts with it; before it is dry, with a dry pencil lay on a small quantity of gold powder. Varnish over all.

Paper. — Gum is substituted for drying oil in bronzing paper. When dry, the paper is submitted to the action of the burnisher, which imparts great brilliancy to it.

Plaster.—Lay the figure over with isinglass size, until it holds out, or without any part of its surface becoming dry; then, with a brush, such as is termed by painters a sash tool, go over the whole, taking care to remove, while it is yet soft, any of the size that may lodge on the delicate parts of the figure. When it is dry, take a little very thin oil *gold size*, and with as much as just damps the brush, go over the figure with it, allowing no more to remain than causes it to shine. Set it aside in a dry place free from smoke, and in forty-eight hours the figure is prepared to receive the bronze.

After having touched over the whole figure with the bronze powder, let it stand another day, and then with a soft dry brush rub off all the loose powder, particularly from the points or more prominent parts of the figure.

Wood.—The wood is first covered with a uniform coating of glue, or of drying oil, and when nearly dry the bronze powder, contained in a small bag, is dusted over it. The surface of the object is afterwards rubbed with a piece of moist rag. Or the bronze powder may be previously mixed with the drying oil, and applied with a brush.

BRONZING POWDERS.

Cheap.—(*a*) Verdigris, 8 oz.; flowers of zinc or tutti powder, 4 oz.; borax and nitre, of each 2 oz.; corrosive sublimate, 2 drachms, made into a paste with oil, and melted together. Used in the commoner kinds of tea-boards, &c.

(*b*) Dissolve copper in aquafortis until it is saturated, and then put into the solution some small pieces of iron, when the copper will be precipitated in the metallic state; the fluid must then be poured off, and the powder carefully washed, dried, and levigated, when it may be put by for use.

(*c*) Bronze powder is sometimes made from Dutch gold, which is sold in books at a very low price. All these inferior bronzes require to be covered with a coat of clear varnish, or they will very soon lose their metallic appearance, nor will the varnish entirely prevent, although it will greatly retard, this change.

(*d*) Mosaic gold, or aurum musivum.—Melt together, in a crucible over a clear fire, equal parts of sulphur and the white oxide of tin. Keep them continually stirred with the stem of an earthenware pipe or glass rod, till they assume the appearance of a yellow flaky powder. An iron rod must not be used in stirring up any mixture of sulphur when melted, or the sulphur and iron will unite. It is rubbed on with the finger.

Another way to prepare it is to take quicksilver, tin, sulphur, and sal ammoniac, equal parts. First melt the tin, then pour the quicksilver into it, afterwards grind up with the amalgam thus made the sulphur and sal ammoniac. Place the mixture in a crucible, and heat until the powder in the crucible becomes gold-coloured, and also until no fumes of quicksilver arise.

Gold.—Leaf gold is ground with virgin honey on a stone, until the leaves are broken up and minutely divided. The mixture is removed from the stone by a spatula, and stirred up in a basin of water, whereby the honey is melted and the gold is set free; the basin is then left undisturbed until the gold subsides; the water is poured off, and fresh quantities are added until the honey is entirely washed away; after which the gold is collected on filtering paper, and dried for use.

Silver.—Bismuth and tin, of each 2 lb.; melt together and add 1 lb. of quicksilver. Pound all together into a powder. This soft fusible amalgam is used as an imitation of silver bronze for plaster figures and other common purposes, in the same way as the aurum musivum is for gold-coloured articles. It may be used as spangles in sealing-wax; it must then be mixed when the resinous part of the wax is getting cold.

BROWNING GUN-BARRELS.

Chloride of antimony has been much used for browning gun-barrels, is excellent in its operation, and has been called, in consequence, browning salt. It is mixed to a thin creamy consistence with olive oil; the iron is slightly heated, dressed evenly upon its surface with this mixture, and left until the requisite degree of browning is produced. The sharpening of the chloride of antimony can be affected by adding a little nitric acid to the paste of olive oil and chloride of antimony, so as to hasten the operation.

Another formula is — Aquafortis, $\frac{1}{2}$ oz.; sweet spirit of nitre, $\frac{1}{2}$ oz.; spirit of wine, 1 oz.; blue vitriol, 2 oz.; tincture of chloride of iron, 1 oz.; water, 40 oz. Dissolve the blue vitriol in the water, then add the other materials, and the water is warmed to dissolve the blue vitriol; let it get cold before adding the other materials. The burnishing and marking can be effected with the burnisher and scratch brush. The polishing is best effected by rubbing with a piece of smooth, hard wood, called polishing wood. It is lastly varnished with shellac varnish, and again polished with the hard wood polisher.

Some prefer the tone of brown produced by blue vitriol, 1 oz.; sweet spirit of nitre, 1 oz.; water, 20 oz.

In any case, the surface of the iron must be well cleaned, and rendered quite bright; it is then freed from grease by rubbing with whiting and water, or better, with powdered quicklime and water. The browning composition is then placed on, and allowed to remain twenty-four hours. It is then rubbed off with a stiff brush. If not sufficiently browned, repeat the last process after browning. Clean the surface well with hot water containing a little soda or potash, and, lastly, with boiling water, and dry it. The surface can be burnished and polished.

Varnish with tinsmith's lacquer, or with gum shellac, 2 oz.; dragon's blood, 3 dr.; methylated spirits of wine, 4 pints. The metal should be made hot before applying this varnish, and will present an excellent appearance. If the varnish is not required to colour, but only to preserve the actual tint produced on the metal surface by the browning fluid, leave out the dragon's blood.

CAMEO CUTTING.

Take the common helmet, or the red helmet shell (those shells whose inner surface is pink or dark coloured are most suitable), cut them into squares with a lapidary's mill, round off the corners, and shape them into an oval on a wet grindstone. Fix the enamel side on a short stick with jeweller's cement, grind off the brittle surface, sketch the subject with a black-lead pencil, cut the subject with engraver's tools, namely, a chisel tool to clear the bare places; a lozenge-shape for forming the subject, and a scraper, made of a three-angled file, ground off taper to the point, for cleaning the enamel surface round the subject, and also for forming the lineaments and other delicate parts. The colour on the cheeks and hair is produced by leaving the layer of coloured shell on those places. The stick must be grasped in the left hand, and held firmly against a steady bench, and with the tool resting in the hollow of the right hand, dig away the shell. A convenient length for the tools is $3\frac{1}{2}$ in.; they must be kept in good condition to work with accuracy. The cameos are polished with a cedar stick, or a piece of cork dipped in oil of vitriol and putty powder, and cleaned with soap and water. Mother-of-pearl is carved in the same way.

CANDLE MAKING.

Animal Fat.—In its natural state, fat of animals is always associated with cellular tissue and other foreign matters, which must be separated before it can be used as candle stock. In dry melting, the rough suet is cut into coarse pieces and exposed to the action of a moderate heat. By more recent processes the fat is not exposed to heat till it has been subjected to mechanical and chemical appliances, for the purpose of destroying the tissues. The first method possesses the decided advantage that the residue can be profitably used as food for hogs and fowls. There is also an economy in fuel, and the simplicity of the process commends itself to inexperienced manufacturers. The disadvantages are an obnoxious smell, from the heating of rough tallow which has been collected and suffered to remain till it has become rancid, and the cellular tissues, blood, or other portions advanced towards putrefaction, and the small amount of fat obtained, as portious always remain with the residue when heated in this manner. The fat for tallow ought to be freed from the membranous and muscular parts, then cut into thin slices and hung up in a cool place, not heaped up while yet warm. By operating thus, the disagreeable odour can be delayed for several days.

Tallow Boiling.—First, the fat is chopped; cutting machines are often used similar to the straw-cutting table; sometimes a thin, sharp-edged, mince-hatchet is employed, about 2½ ft. in length. This is held with both hands, and the fat, spread out on a beech block, is chopped into small pieces in all directions. A third instrument is a kind of stamp trough with muller, having a sharp blade in the form of an S, a contrivance frequently adopted for cutting beets. A more desirable instrument, however, is the ordinary rotary sausage-cutter. The fat is then placed in melting caldrons, hemispherical in form, and made of cast iron, which are heated by open fire. These caldrons are covered with movable tinplate hoods, so adjusted that, by means of pulleys, ropes, and counter-weights, they can be easily raised or lowered, whilst, at the same time, they serve to carry off the offensive vapours arising from the heated fat. Water is sometimes mixed with the fat in the caldrons, and this addition is specially beneficial when the fat has been long kept during the summer months, and has thereby lost its natural moisture by evaporation. By gradually raising the temperature in the pan, the fat runs from the cells, and the whole is kept boiling from 1 to 1½ hour. During the whole operation of melting and boiling, the ingredients must be constantly stirred in order to keep the fat and cracklings in incessant agitation, otherwise pieces of unmelted suet, coming in contact with the sides or bottom, would become scorched and acquire a brownish tint, of which the whole melting would necessarily partake. Scorched tallow is not readily whitened. For separating the melted fat from the cracklings, it is ladled off from the caldron into a fine willow basket, or a copper box perforated at the bottom with innumerable small holes, set over large copper coolers, and allowed to remain undisturbed till all foreign matters have settled down. Before it congeals, it should be transferred into small wooden pails. This operation is continued so long as the cracklings yield any fat; and during the process the heat must be maintained at a moderate degree, to avoid scorching the materials. When the cracklings begin to harden they acquire a darkish tint, and hence are said to be browning. They are then pressed, and the fat thus obtained possesses somewhat of the brown colour of the cracklings, but not so much as to render it unfit for use as soap stock; it may, consequently, be mixed with that which has spontaneously separated while heating.

Clarifying Tallow.—By mere melting and straining we do not obtain a fat entirely free from admixture of fine, undissolved substances. For separating these substances, it must be clarified, by remelting it in water, either on free fire or by steam. Generally, no more water than 5 per cent. is taken, and stirred well with the fat till the mixture becomes emulsive. The whole is then allowed to rest, without further heating, till the water has separated, when the fat may be drawn off, or dipped off. Sometimes, to conceal the yellowish tint, a very little blue colour is added, consisting of indigo rubbed finely with some oil, of which a few drops are sufficient for large quantities of tallow. The process of clarifying is occasionally repeated. At the line of demarcation between the water and fat, a grey slimy substance is often perceptible, and the liquid itself is turbid. Instead of pure water, some tallow-melters take brine or solutions of alum, saltpetre, chloride of ammonium, or other salts. These agents have no chemical action upon the fats, but simply induce a more rapid settling of the impurities and water, principally when strong agitation is used.

Ozokerit.—This mineral is used in the production of illuminating oils of a high firing point, and of solid hydrocarbons, more particularly adapted to the manufacture of candles of a high melting point; the raw material is distilled by heat, thereby producing an oily distillate, the solid and liquid constituent parts of which are then separated by pressure. The pressed solid material is purified by mixing and stirring with sulphuric acid when melted. After standing for some time, in order to effect the complete separation from the acid, the supernatant melted material is carefully decanted off, and thoroughly washed with hot water. The water having been removed, the material is repeatedly filtered through animal charcoal until the requisite degree of whiteness is attained.

Wicks.—Wicks are twisted or plaited; the former, loosely twisted, present the appearance of a spiral similar to the separate strands of a rope; the latter, now generally adopted for most kinds of candles, is made by interlacing and crossing the strands of the wicks in the same manner as plaiting straw of bonnets. Common wicks are simply an aggregation of several loosely-twisted threads forming one general cord of many fibres. The yarn employed is No. 16. For tallow candles, 8 to the lb., the wick contains 42 threads; 7 to the lb., 45 threads; 6 to the lb., 50 threads; 5 to the lb., 55 threads, 4 to the lb., 60 threads. These wicks, composed of 10, 12, or even 16 cords, are very loosely twisted, and form a kind of hollow tube. For stearine candles, three-corded plaited wicks are generally used, smaller in size and of finer yarn. Stearine candles, 4 to the lb., the wicks consist of 108 threads; 5 to the lb., 96 threads; 6 to the lb., 87 threads; 8 to the lb., 63 threads.

Preparing Wicks.—This is done by wick-mordants, by means of which they are rendered less combustible, especially those for stearine and composite candles. Compounds composed of solutions of ammoniac salts, of bismuth, of borates, or boracic acid, are used. A simple and cheap mordant for wicks is a sal ammoniac solution of 2° to 3° B. This concentration is strong enough, and if a weaker one be used, a spark will remain on the wick after the candle has been blown out, and burning down to the fat, made relighting more difficult. Before moulding is performed, the wicks, having been saturated, are thoroughly dried in a tin box, surrounded by a jacket, in which steam is introduced. Instead of the sal ammoniac, phosphate of ammonia is used in some factories. A very good mordant is also a solution of $2\frac{4}{10}$ oz. boracic acid in 10 lb. of water, with $\frac{1}{3}$ oz. of strong alcohol, and a few drops of sulphuric acid. Some mordants have become unpopular; the fault is in the crude cotton, which does not always readily become moistened; consequently, from not having completely imbibed the mordant, portions of the thread remain unsaturated, and are not equally combustible with the others. An admixture of alcohol will remedy this defect, as cotton is more easily moistened in dilute spirit than in pure water.

Dips.—These candles are made by stringing a certain number of wicks upon a rod, and dipping them in melted tallow repeatedly. The process is very simple; the clarified and remelted tallow is poured into a tightly-joined walnut or cherry trough, 3 ft. long by 2 ft. wide, and 10 to 12 in. wide at the top, gradually diminishing to 3 or 4 in. at the bottom. A handle is fixed on each end for its easy removal, and when not in use it is closed with a cover. The operator commences by stringing 16 to 18 wicks at equal intervals on a thin wooden rod, about $2\frac{1}{2}$ ft. long, and sharpened at the ends. He then takes 10 or 12 such rods and dips the wicks rapidly into the fluid tallow in a vertical direction. The tallow should be very liquid, in order that the wicks be soaked as uniformly as possible, after which the several rods are rested on the ledges of the trough, when, if any of the wicks be matted together, they are separated, and the rods so placed on a frame, having several cross-pieces, that the uncongealed tallow from the wicks may drop down, and while this is going on, which continues till the tallow is cooled and solidified, the operator is engaged in preparing another batch of rods. The fat in the trough, meanwhile, is so far cooled that in immersing the first dip again a thicker layer will adhere to the wicks. It is considered that when the tallow solidifies at the sides of the vessel, the temperature is the most convenient for the object in view. It is sometimes necessary to stir the ingredients to produce a uniform admixture, and in such cases much care should be taken so that no settlings be mingled with the mass, whilst by the addition of hot tallow any desired temperature may be obtained. The tallow on the wicks after each dipping becomes so gradually hardened, that at the third or fourth immersion new layers necessarily solidify ; as a natural consequence of the method of dipping, the lower ends of the wicks become thicker than the upper, to remedy which the lower ends are again put into the melted fat for a few minutes, when the heat, as a matter of course, diminishes their dimensions. The process of dipping is continued until the candles acquire the requisite thickness. The conical spire at the upper end is formed by immersing deeper at the last dip, and if, eventually, the candles are too thick at the lower end, they are held over a slightly-heated folded copper sheet, so that the fat may melt, but not be wasted.

Moulds. — For moulding, common metal moulds, a mixture of tin and lead, are used. They are slightly tapering tubes, varying in length and dimensions according to the size of the candle to be manufactured, and, when required, are arranged in regularly-perforated wooden frames or stands, with the smaller end downwards, forming the upper or pointed part of the candle. At this smaller end, the wick, previously saturated in melted fat, is inserted, filling the aperture, and, passing up the centre, is fastened perpendicularly at the upper end of the tube, to which is attached a movable cover. The melted fat is then poured in, generally with a small can, but a tinned iron siphon is better. It is requisite that the tallow should completely fill the mould, that it should remain uncracked on cooling, and should be easily removable from the moulds. This can, however, only be obtained when the fat at the sides cools more quickly than that in the interior, and when the whole candle is rapidly cooled. A cool season is, for this reason, far better; but a certain condition of the tallow, namely, that which it possesses at a temperature very near its melting point, is absolutely necessary. Candle-makers recognise the proper consistence of the tallow for moulding by the appearance of a scum upon the surface, which forms in hot weather between 111° and 119° F., in mild weather at 108° F., and in cold about 104° F. The tallow is usually melted by itself, sometimes, however, over a solution of alum. The candles are most easily removed from the mould the day after casting, to be cut and trimmed at the base. Moulding by hand is a very tedious operation, and only practised in the smaller factories ; in more extensive establishments, where economy of time and labour is a consideration, machinery is employed.

Composite Candles.—Melt together, over a water bath, 100 parts of stearic acid, and 10 to 11 parts of bleached beeswax ; but, to ensure success, the mixture must remain over the bath from 20 to 30 minutes, without being stirred or agitated. At the end of that time the fire is to be extinguished, and the fluid allowed to cool until a slight pellicle is formed on the surface, when it is cast direct into the moulds, previously heated to the same temperature, with the precaution of avoiding stirring the mixture, which would cause opaqueness.

Transparent Candles.—For 100 lb. of stock take 90 lb. of spermaceti, 5 lb. purified mutton suet, and 5 lb. wax; melt each separately over a water bath, and to the whole, when mixed together, add 2 oz. of alum and 2 oz. of bitartrate of potash in fine powder; and, while stirring constantly, raise the heat to 176° F.; then withdraw the fire and allow the mixture to cool to the temperature of 140° F. When the impurities subside, the clear liquid must be drawn off into clean pans. Paraffin wax is an excellent substitute, and much less costly. For quality and good appearance, candles made of this cooked block are more than proportional to its cost. Substitute plaited wicks for the foregoing mixture to the wicks generally used for composite candles, and prepare them by previously soaking in a solution of 4 oz. borax, 1 oz. chlorate of potash, 1 oz. nitrate of potash, and 1 oz. sal ammoniac, in 3 quarts of water. After being thoroughly dried, they are ready for moulding.

Diaphane.—It is made by melting together, in a steam-jacket, 2½ to 17½ lb. of vegetable wax, 1½ to 10½ of pressed mutton tallow, and 22 to 46 lb. of stearic acid. The latter and the vegetable wax are the hardening ingredients. By changing the proportions between the above limits, a more or less consistent mixture may be formed. The moulding is performed in the same manner as for stearic-acid candles.

Snuffless Wicks.—The great objection to tallow candles is the frequent necessity for removing the snuff, or charred wick, which rises into the body of the flame and obscures the light. If the wick can be exposed to the air it will be entirely consumed. (*a*) This is done in composite candles by plaiting the cotton into a flat wick, which as it burns curves over. Sometimes a very fine wire is included in the wick, which is usually dipped in a solution of borax. (*b*) Twist the wick with one strand shorter than the others, which will bend the wick slightly when the fat melts.

For a more detailed account of candle making on the industrial scale, see Spons' Encyclopædia.

CATGUT MAKING.

Take the entrails of sheep, or any other animal, procured from the newly-killed carcase. Thoroughly clean them from all impurities and from attached fat, and wash them well in clean water; soak in soft water for two days, or in winter three days, then lay them on a table and scrape them with a small plate of copper, having a semicircular hole cut in it, the edges of which must be quite smooth and not capable of cutting. Now, after washing, put them into fresh water, and there let them remain till the next day, when they are again to be scraped. Let them soak again in water for a night, and two or three hours before they are taken out add to each gallon of water 2 oz. of pearlash. They ought now to scrape quite clean from their inner mucous coat, and will consequently be much smaller in dimensions than at first. They may now be wiped dry, slightly twisted, and passed through a hole in a piece of brass, to equalise their size; as they dry, they are passed every two or three hours through other holes, each smaller than the last. When dry they will be round and well polished, and being oiled are fit for use. (See also ii. 319.)

CEMENTS.

(ii. 62; v. 13.)

Acid Proof.—Make a concentrated solution of silicate of soda, and form a paste with powdered glass. This simple mixture will sometimess be found invaluable in the operations of the laboratory where a luting is required to resist the action of acid fumes. (See also ii. 62, v. 13.)

Aquarium.—(*a*) Take 1 gill of plaster of Paris, 1 gill of litharge, 1 gill of fine white sand, ⅓ of a gill of finely-powdered rosin. Mix well, and bottle and cork it until wanted for use, then mix it with boiled oil and dryers until as thick as putty. Mix the cement only in small quantities, as it dries quickly.

(*b*) Mix boiled linseed oil, litharge, red and white lead together, using white-lead in the largest proportion; spread on flannel, and place on the joints.

(*c*) A solution of glue, 8 oz. to 1 oz. of Venice turpentine; boil together, agitating all the time, until the mixture becomes as complete as possible, the joints to be cemented to be kept together for forty-eight hours if required.

(*d*) Take ½ a gill of gold size, 2 gills of red-lead, 1½ gill of litharge, and sufficient silver-sand to make it into a thick paste for use. This mixture sets in about two days. (See also ii. 66.)

Architectural. — Strong rice-water size and paper pulped in boiling water are mixed together; enough whiting is then added to make it of a proper consistence. (See also ii. 67.)

Armenian, or Jewellers'.—Dissolve 5 or 6 bits of gum mastic, the size of a large pea, in as much spirits of wine as will suffice to render it liquid; in a separate vessel dissolve as much isinglass (previously softened in water, though none of the water must be used) in rum, or other spirit, as will make a 2-oz. phial of very strong glue, adding two small pieces of gum ammoniacum, which must be rubbed or ground till they are dissolved; then mix the whole with a sufficient heat. Keep it in a phial closely stopped, and when it is to be used, set the phial in boiling water. The preceding is also effectual in uniting almost all substances, even glass to polished steel. (See also ii. 67.)

Chinese.—Finest pale orange shellac, broken small, 4 oz.; rectified spirit (the strongest, 58 o.p.) 3 oz.; digest together in a corked bottle in a warm place until dissolved; it should have the consistence of treacle. For wood, glass, ivory, jewellery, and also fancy works. (See also ii. 72, v. 18.)

Cutlers'.—(*a*) Rosin, 4 parts, to 1 part beeswax and 1 part of brick-dust, or plaster of Paris.

(*b*) 16 parts rosin, 16 hot whiting, and 1 wax.

(*c*) Pitch, 4 parts; rosin, 4; tallow, 2; and brick-dust, 2.

The opening for the blade is filled with one of these compositions. The lower end of the iron is heated and pressed in. (See also ii. 73, v. 13.)

Elastic.—Bisulphide of carbon, 4 oz.; fine rubber in shreds, 1 oz.; isinglass, 2 dr.; gutta-percha, ½ oz.; dissolve. Used for cementing leather or rubber. The parts to be joined must be coated thinly with the solution, and allow a few minutes to dry, then heat to melting; place the parts together and well hammer the air bubbles out. (See also ii. 74, v. 17.)

Electrical or Chemical. — A good cement for chemical and electrical apparatus may be prepared by mixing 5 lb. of rosin, 1 lb. of wax, 1 lb. of red ochre, and 2 oz. of plaster of Paris, and melting the whole with moderate heat. (See also ii. 70.)

Engineers'. — (*a*) Mix ground white-lead with as much finely-powdered red-lead as will make it the consistence of soft putty.

(*b*) Mix equal parts of white-lead and red-lead, and add as much boiled linseed oil as is required to give it the proper consistence; or boiled linseed oil and red-lead mixed into a putty. These cements are used for making metallic joints sound. (See also ii. 74.)

Fireproof and Waterproof.—(*a*) To 4 or 5 parts of clay, thoroughly dried and pulverised, add 2 parts of fine iron filings free from oxide, 1 part of peroxide of manganese, ½ part of sea salt, and ½ part of borax. Mingle these thoroughly and render them as fine as possible, then reduce them to a thick paste with the necessary quantity of water, mixing thoroughly well. It must be used immediately. After application it should be exposed to heat, gradually increasing almost to a white heat. This cement is very hard, and presents complete resistance alike to a red heat and boiling water.

(*b*) To equal parts of sifted peroxide of manganese and well-pulverised zinc white, add a sufficient quantity of commercial soluble glass to form a thin paste. This mixture, when used immediately, forms a cement quite equal in hardness and resistance to that obtained by the first method. (See also ii. 74.)

Fire Lutes.—(*a*) Mix thoroughly 2 parts good clay, 8 parts sharp washed sand, 1 part horse-dung, then temper like mortar.

(*b*) Linseed or almond meal mixed to a paste with milk, lime-water, or starch-paste. This lute stands to 500° F.

(*c*) Mix dry clay in powder with drying oil into a thick paste. The part to which this is applied must be clean and dry.

(*d*) Plaster of Paris mixed with water, milk, or weak glue. Both (*c*) and (*d*) stand a dull red heat.

Glue. *Manufactured from Bones.*—The first process is to cleanse the bones by immersing them in a pit or cistern of water, where they remain about 12 hours; the water is then drawn off, and fresh water added to them; this operation is sometimes repeated to remove any dirt. The water being withdrawn from the bones, a solution of lime, in the proportion of 1 bushel of lime to 500 gallons of water, is poured into the cistern for the more perfect cleansing of the bones and the removal of any superfluous matter. After 3 or 4 days' saturation, the lime solution should be drawn off and fresh water added to get rid of the lime. Thus prepared, the bones are placed in a hollow globular vessel of wrought iron, called an extractor, which is filled with them by removing the interior plate which covers the manhole; this aperture is of an elliptical form, and allows the plate to be slipped round and refixed in its place by turning a nut, which draws it up tight against the interior surface of the extractor, and the junctures are made air-tight by luting. The extractor turns upon a horizontal cylindrical shaft; one half of this shaft is made hollow, or consists of a strong tube, which tube also proceeds downwards towards the centre of the vessel to conduct the steam beneath the grating upon which the bones are laid. The steam, of about 15 lb. pressure, is admitted by the cylindrical shaft, proceeds first to the bottom of the extractor, then rises up through the grating and amongst the bones, until the vessel is completely charged; previous to this, however, the air in the extractor is got rid of by opening a cock at the top of the extractor, and closing it after the admission of steam. While the steam is acting upon the bones the extractor is occasionally turned round by means of a hand-winch. When at rest, a quantity of fluid gelatine is collected at the bottom of the extractor, from whence it is discharged by means of a cock into a tub beneath, after opening the air-cock to enable it to run off. This done, steam is again admitted from the boiler into the extractor to act upon the bones for another hour, when the second portion of condensed liquor is drawn off. When the products thus obtained have become cold, the fat which has formed upon the surface is carefully removed by skimming, and the gelatinous portion only is to be returned into the extractor by means of a funnel through the cock on the top. The steam is then admitted to the extractor for an hour, after which it is finally drawn off into another vessel to undergo a simple evaporating process until it arrives at a proper consistency to solidify when cold, previous to which some alum is added to clarify it. When cold, this gelatinous mass is cut out into square cakes, and dried as usual in the open air.

Common Glue.—(*a*) Common glue is extracted from hoofs, horns, and cuttings of the hides of various animals. For this process the materials are first steeped in water for 2 or 3 days, well washed, and afterwards boiled to the consistency of a thick jelly, which is passed while hot through osier baskets to separate the grosser particles of dirt or bones from it, and allowed to stand some time to purify further. When the remaining impurities have settled to the bottom, it is melted and boiled a second time. It is next poured into flat frames or moulds, from which it is taken out hard and solid, and cut into square pieces or cakes, and afterwards dried in the wind in a coarse kind of net.

(*b*) Substances intended for the glue-maker are macerated with milk of lime for 14 days, and dried by exposure to the air; they can then be transported to any distance without undergoing decomposition. The manufacturer generally treats the materials again with dilute milk of lime; afterwards they are carefully washed and exposed to the air for about 20 or 30 hours. They are then placed in a copper boiler having a perforated false bottom, which supports the materials and prevents their being burnt; the boiler is filled about two-thirds with water, and is piled up with the animal substances until they are level with the brim; a gentle but steady boil should be maintained, and the substances should be stirred from time to time. When the liquor on cooling forms a firm gelatinous mass, the clear portion is run off into another vessel, and a small quantity of dissolved alum is added. It is kept warm by means of hot water, and allowed to remain undisturbed for some hours to deposit its impurities; it is next run into the congealing boxes, and left to cool. When cold, the masses are turned out upon boards wetted with water, cut into small cakes, and these cakes are placed upon nettings to dry. The dry cakes are then dipped into hot water, and lightly rubbed with a brush to give them a gloss, and lastly stove-dried for sale. This furnishes the best and palest glue. After the first liquor is drawn from the copper, the remnants left in the boiler are treated with fresh water, again and again, until no gelatinous matter can be extracted.

Melting.—Break the glue into small pieces and soak for 12 to 24 hours in cold water; put the glue in the glue-pot, fill the outer vessel with water, and apply heat. For ordinary purposes it should run freely, and be of the consistency of thin treacle. The hotter glue is, the more force it will exert in keeping the two parts glued together; in all large and long joints, the glue should be applied immediately after boiling. Glue loses much of its strength by being often melted; that glue, therefore, which is newly made is much preferable to that which has been used. When done with, add some of the boiling water from the outer vessel to the glue, so as to make it too thin for use. Put it away till wanted again, and by the time the water in the outer vessel is boiled, the glue in the inner is ready melted and of the proper thickness for use. Powdered chalk, brick-dust, or saw-dust added to glue, will make it hold with more than ordinary firmness.

ELASTIC GLUE.—Dissolve glue by the aid of a water bath, evaporate till a thick fluid is obtained, add an equal weight of glycerine, continue the evaporation with stirring until the remaining water is driven off; run it out on a marble slab to cool. This composition might be advantageously applied to the manufacture of printers' rollers, and similar articles.

LIQUID GLUE.—(*a*) Soft water, 1 quart; best pale glue, 2 lb.; dissolve in a covered vessel by the heat of a water bath; after cooling, add with caution 7 oz. of nitric acid; when cold, bottle off.

(*b*) White glue, 16 oz.; dry white-lead, 4 oz.; soft water, 2 pints; alcohol, 4 oz.; stir together, and bottle while hot.

(*c*) 3 parts glue broken into small pieces should be covered with 8 parts of water, and left to stand for some hours; ½ part of hydrochloric acid and ¾ part of sulphate of zinc must then be added, and the whole exposed to a temperature of about 185° F. during 10 or 12 hours. Allow the compound to settle.

(*d*) A liquid glue possessing great resisting power, recommended for wood and iron, is prepared, according to Herz, as follows:—Clear gelatine, 100 parts;

cabinet-makers' glue, 100 parts; alcohol, 25 parts; alum, 2 parts; the whole mixed with 200 parts of 20 per cent. acetic acid, and heated on a water-bath for 6 hours.

(*e*) An ordinary liquid glue, also well adapted for wood and iron, is made by boiling together for several hours 100 parts glue, 260 parts water, and 16 parts of nitric acid.

MARINE GLUE.—(*a*) Dissolve by heat 1 part of pure rubber in naphtha; when melted add 2 parts shellac; melt until mixed. Pour while hot on metal plates to cool; when required to use, melt and apply with a brush.

(*b*) Caoutchouc, 20 gr.; chloroform, 2 fl. oz.; dissolve and add 4 dr. of powdered mastic; let it macerate for a week; must be kept cool and well corked.

PORTABLE, OR MOUTH GLUE.—Fine pale glue, 1 lb.; dissolve over a water bath in sufficient water, add brown sugar, ¼ lb.; continue the heat till amalgamation is effected; pour on a slab of slate or marble, and when cold cut into squares. Used by moistening with the tongue. (See also ii. 78, 300.)

Gum.—*Mucilage for Labels.*—Macerate 5 parts of good glue in 20 parts of water for 24 hours, adding 20 parts of rock candy, and 3 parts of gum arabic.

Preserving Gum-Arabic Solutions.—A few drops of oil of cloves, or of alcohol, or any essential oil, will preserve a quart of the mucilage of gum arabic or gum tragacanth from turning sour.

Artificial or British Gum. — Malt, crushed small, 1 lb.; warm water, 2 gal. Mix; heat the whole to 145° F.; add of potato starch 5 lb.; raise the heat to 160° F., and mash for about 25 minutes, or until the liquid becomes thin and clear; it must then be instantly run off, and raised to the boiling point to prevent the formation of sugar; after boiling for 3 or 4 minutes, the whole must be filtered and evaporated to dryness by a steam heat. (See also ii. 73, 85, 450.)

Impervious.—Zinc white, rubbed up with copal varnish to fill up the indentures in corks; when dry, to be covered with the same mass, somewhat thinner; and lastly, with copal varnish alone. (See also ii. 73.)

Indianite.—(*a*) 100 parts finely-chopped rubber, 15 rosin, 10 shellac, dissolved in a sufficient quantity of bisulphide of carbon. Used for uniting pieces of rubber.

(*b*) Rubber, 15 gr.; chloroform, 2 oz.; mastic, ½ oz. The two first-named to be mixed, and after the rubber is dissolved add the mastic in powder; allow to macerate for a week.

Iron Pots and Pans.—Take 2 parts of sulphur, and 1 part, by weight, of fine black-lead; put the sulphur in an old iron pan, holding it over the fire until it begins to melt, then add the graphite; stir well until all is mixed and melted; then pour out on an iron plate, or smooth stone. When cool, break into small pieces. A sufficient quantity of this compound being placed upon the crack of the iron pot to be mended, can be soldered by a hot iron in the same way a tinsmith solders his sheets. If there is a small hole in the pot, drive a copper rivet in it and then solder over it with this cement. (See also ii. 89.)

Iron Railings.—For the cementing of iron railing tops, iron gratings to stoves, &c., the following mixture is recommended; in fact, with such effect has it been used as to resist the blows of a sledge-hammer. This mixture is composed of equal parts of sulphur and white-lead, with about one-sixth proportion of borax, the three being thoroughly incorporated together, so as to form one homogeneous mass. When the application is to be made of this composition, it is wet with strong sulphuric acid, and a thin layer of it is placed between the two pieces of iron, these being at once pressed together. In five days it will be perfectly dry, all traces of the cement having vanished, and the work having every appearance of welding.

Iron Rust Joints.—(*a*) 1 lb. clean iron borings, pounded fine in a mortar, 2 oz. sal ammoniac in powder, 1 oz. flowers of sulphur. The whole mixed by pounding, and to be kept dry.

For use, mix 1 part of the above with 20 of iron borings pounded, adding water to the consistence of mortar.

(*b*) 2 lb. clean iron borings, 1 oz. flowers of sulphur, 1 oz. sal ammoniac.

(*c*) 98 parts of fine iron borings through a sieve, 1 flowers of sulphur, 1 sal ammoniac. Mix and dissolve in boiling water when required for use.

(*d*) Mix 1 lb. fine borings, ½ oz. sal ammoniac, pounded small, ½ oz. spirits of salts, and a little water. Prepare the joint by bringing the inner joint rings of the flanges together—screwing up the bolts firmly; in this condition there should be an annular space between the flanges of from ¼ in. to ⅜ in. in width; a strand of rope-yarn or any soft fibre should now be stuffed to the bottom of the joint, so as to prevent the jointing material from being driven through in the process of caulking. A good hammer, a caulking iron rather thinner than the joint, and a flat piece of wood or sheet iron should be in readiness. Take a suitable quantity of fine cast-iron borings, free from dust, and which may be passed through a sieve to remove large pieces; next dissolve a very small piece of sal ammoniac in water, say a drachm to a quart. In the absence of sal ammoniac to mix up the borings with, the urine of any animal does quite as well. Now mix the borings with sufficient of the fluid to cause them to adhere together in lumps when compressed in the hand. It is now ready for use. By means of the caulking iron, and the piece of board or plate, stuff the moist material into the joint to a depth of 1 in. or so from the bottom, all round; now caulk it down with the iron and hammer until it sounds perfectly solid, as though it struck against solid iron. Repeat the process of filling, then the caulking, and so on, until the joint is filled to the surface. The joint should rest for at least ten hours before being put under pressure. (See also ii. 89.)

Ivory, or Mother-of-Pearl.—Dissolve 1 part of isinglass and 2 of white glue in 30 of water, strain and evaporate to 6 parts. Add $\frac{1}{30}$th part of gum mastic, dissolved in ½ a part of alcohol, add 1 part of zinc white. When required for use, warm and shake up. (See also ii. 90.)

Jet.—Shellac is the only cement used by jewellers for jet articles. The broken edges should be made warm before applying the cement. Should the joint be in sight, by smoking the shellac before applying it, it will be rendered the same colour as the jet itself.

Leather.—A good cement for splicing leather for straps is gutta-percha dissolved in bisulphide of carbon, until it is of the thickness of treacle; the parts to be cemented must first be well thinned down, then pour a small quantity of the cement on both ends, spreading it well so as to fill the pores of the leather, warm the parts over a fire for about half a minute, apply them quickly together, and hammer well. The bottle containing the cement should be tightly corked and kept in a cool place. (See also ii. 92.)

London.—Boil a piece of Gloucester cheese three times in water, each time allowing the water to evaporate. Take the paste thus left and thoroughly incorporate with dry quicklime. It will mend glass, wood, china, &c., very effectually.

Marble.—Take plaster of Paris, and soak it in a saturated solution of alum, then bake in an oven, the same as gypsum is baked to make plaster of Paris; after which grind the mixture to powder. It is then used as wanted, being mixed up with water like plaster, and applied. It sets into a very hard composition capable of taking a very high polish, and may be mixed with various colouring minerals to produce a cement of any colour capable of imitating marble. This cement is also used for attaching glass to metal. (See also ii. 93.)

Meerschaum.—(*a*) Take some garlic and crush it, in order to form a kind of dough, rub over the broken pieces of meerschaum with it and reunite them by drawing very closely; bind them with iron wire according to the strength of the pieces, and finally make them boil during half an hour in a sufficient quantity of milk.

(*b*) Use quicklime mixed to a thick cream with the white of an egg. These cements will also unite glass or china. (See also ii. 95.)

Metals, or Glass and Wood.—(*a*) Melt rosin and stir in calcined plaster until reduced to a paste, to which add boiled oil in sufficient quantity to bring it to the consistence of honey; apply warm.

(*b*) Melt rosin 180 parts, and stir in burnt umber, 30; calcined plaster, 15; and boiled oil, 8 parts.

(*c*) Dissolve glue in boiling water to the consistence of cabinet-maker's glue, then stir in sufficient wood ashes to produce a varnish-like mixture. While hot, the surfaces to be united must be covered with this compound and pressed together. (See also ii. 95.)

Parchment Paper.—The best cement for pasting parchment paper is casein glue. It is much better than so-called chrome glue, because the latter produces yellow or brownish spots where it has been employed. Casein glue is a solution of casein, which appears as whey or drop when milk is allowed to curdle. The glue is dissolved in a saturated solution of borax. When dried in the form of transparent gelatine, it appears as greyish white and somewhat brittle matter, which can be easily dissolved in water, and possesses great adhesiveness. When employed for pasting parchment paper, a thin paste is prepared, used in the customary manner, and the jointed places are afterwards exposed for a little while to a jet of steam.

Paste, Bookbinders'. — Place half a quartern of flour in a saucepan, put as much cold water on it as will cover it, and stir it well up, so as to break all the lumps while in a state of dough. Then pour on about 2 quarts of cold water and 1 oz. of powdered alum. Stir well and boil till it becomes thick. (See also ii. 98.)

Plumbers'.—Black rosin, 1 part; brick-dust, 2 parts; well incorporated by a melting heat.

Prints.—Fine wheat starch, 4 dr., beat into a paste with cold water; 1 oz. of best Russian glue dissolved in a pint of boiling water; while boiling, pour on the starch; put the whole into a saucepan, and boil till as thick as treacle. When required for use a small quantity is to be melted in a little warm water.

Rubber. — Cut virgin or native rubber with a wet knife into the thinnest possible slices, and with shears divide these into threads as fine as fine yarn. Put a small quantity of the shreds (say $\frac{1}{10}$th or less of the capacity of the bottle) into a wide-mouthed bottle, and fill it three-quarters full with benzine of good quality, perfectly free from oil. The rubber will swell up almost immediately, and in a few days, especially if often shaken, assume the consistence of honey. If it incline to remain in undissolved masses, more benzine must be added; but if too thin and watery, it needs more rubber. A piece of solid rubber the size of a walnut will make a pint of the cement.

This cement dries in a few minutes, and by using three coats in the usual manner, will unite leather straps, patches, rubber soles, backs of books, &c., with exceeding firmness. (See also v. 17.)

Stonemasons'.—Clean river sand, 20 lb.; litharge, 2 lb.; quicklime, 1 lb.; linseed oil, sufficient to form a thin paste. This cement is applied to mend broken pieces of stone, and after a time it becomes exceeding hard and strong. A similar composition has been used to coat brick walls, under the name of mastic. (See also ii. 108, v. 18.)

Turners'. — (*a*) Take Burgundy pitch, 2 lb.; rosin, 2 lb.; yellow wax, 2 oz.; dried whiting, 2 lb.: melt and mix.

(*b*) Black rosin, ½ lb.; yellow wax, 1 oz.; melt together, and pour into a tin canister. When wanted for use, chip out as much as will cover the chuck to $\frac{1}{10}$th of an inch, spread it over the surface in small pieces, mixing it with an eighth of its bulk of gutta-percha in thin slices; then heat an iron to a dull red heat, and hold it over the chuck till the mixture and gutta are melted and liquid; cool the iron a little and with it stir the cement until it is homogeneous; chuck the work, lay on a weight to enforce contact, leave it at rest for half an hour, when it will be ready for the lathe.

(*c*) Four parts rosin melted with 1 part pitch; while these are boiling add brick-dust until by dropping a little upon a cold stone you think it hard enough. (See also ii. 109.)

Wood Cracks.—(*a*) Make a paste of slaked lime, 1 part; rye meal, 2 parts; with a sufficient quantity of linseed oil.

(*b*) Dissolve 1 part of glue in 16 parts of water, and when almost cool stir in saw-dust and prepared chalk a sufficient quantity.

(*c*) Oil-varnish thickened with a mixture of equal parts of white-lead, red-lead, litharge, and chalk.

Wood Vessels.—A mixture of lime-clay and oxide of iron separately calcined and reduced to fine powder, then intimately mixed, kept in a close vessel, and mixed with the requisite quantity of water when used.

Using Cements.—Take as small a quantity of the cement as possible, and bring the cement itself into intimate contact with the surfaces to be united. If glue is employed, the surface should be made so warm that the melted glue is not chilled before it has time to effect a thorough adhesion. Cements that are used in a fused state, as rosin or shellac, will not adhere unless the parts to be joined are heated to the fusing point of the cement. Sealing-wax, or ordinary electrical cement, is a good agent for uniting metal to glass or stone, provided the masses to be united are made so hot as to fuse the cement, but if the cement is applied to them while they are cold it will not stick at all. This fact is well known to the itinerant vendors of cement for uniting earthenware. By heating two pieces of china or earthenware so that they will fuse shellac, they are able to smear them with a little of this gum, and join the pieces so that they will rather break at any other part than along the line of union. But although people constantly see the operation performed, and buy liberally of the cement, it will be found in nine cases out of ten that the cement proves worthless in the hands of the purchasers, simply because they do not know how to use it. They are afraid to heat a delicate glass or porcelain vessel to a sufficient degree, or they are apt to use too much of the material, and the result is a failure.

CLEANSING.

(ii. 111.)

Alabaster. — Strong soap and water is good for cleaning alabaster; if too much discoloured make a paste with quicklime and water, cover the article well with it, and let it remain all day; wash off with soap and water, rubbing hard the stains. Or apply dilute muriatic acid, having previously washed off dirt and grease.

Brass or Copper.—Take 1 oz. of oxalic acid, 6 oz. rottenstone, ½ oz. gum arabic, all in powder, 1 oz. sweet oil, and sufficient of water to make a paste. Apply a small portion, and rub dry with a flannel or leather. (See also ii. 111, 114.)

Brass Inlaid Work.—Mix tripoli and linseed oil, and dip felt into the preparation. With this polish. If the wood be rosewood or ebony, polish it with finely-powdered elder ashes, or make a polishing paste of rottenstone, a pinch of starch, sweet oil, and oxalic acid, mixed with water.

Engravings.—Put the engraving on a smooth board, cover it thinly with common salt finely pounded; squeeze lemon-juice upon the salt so as to dissolve a considerable portion of it; elevate one end of the board, so that it may form an angle of about 45 or 50 degrees with the horizon. Pour on the engraving boiling water from a tea-kettle, until the salt and lemon-juice be all washed off; the engraving will then be perfectly clean, and free from stains. It must be dried on the board, or on some smooth surface, gradually. If dried by the fire or the sun, it will be tinged with a yellow colour. (See also ii. 115.)

Hands.—For cleaning the hands when stained with chemicals :— Put ¼ lb. glauber salts, ¼ lb. chloride of lime, and 4 oz. of water into a small wide-mouth bottle, and when required for use pour some of the thick sediment into a saucer and rub it well over the hands with pumice or a nail brush. Stains of nitrate of silver may be removed from the hands by means of a solution of chloride of iron.

Hats.—The stains of grease and paint may be removed from hats by means of turpentine, and if the turpentine leaves a mark finish with a little spirits of wine.

Jewellery. — Common jewellery may be effectually cleaned by washing with soap and warm water, rinsing in cold water, dipping in spirits of any kind, and drying in warm *boxwood* sawdust. Good jewellery only needs washing with soap and water, and polishing with rouge and a chamois leather.

Marble.—Mix up a quantity of the strongest soap-lees with quicklime, to the consistence of milk, and lay it on the stone for twenty-four hours; clean it afterwards, and it will appear as new.

This may be improved by rubbing afterwards with fine putty powder and olive oil. (See also ii. 125.)

Metals.—Mix ½ pint of neat's-foot oil, and ½ gallon of spirit of turpentine ; wet a woollen rag with some of this and put on it a little powder, made thus :— Take 2 oz. green copperas and ½ oz. sub-carbonate of potash, burn these together in a clay vessel for a quarter of an hour in the fire, when it should be reduced to an impalpable powder for use. Having put the powder in the oiled part of the rag, well rub the metal ; wipe off with a soft cloth, and polish with a dry leather and some more powder.

Pearls.—Soak them in hot water in which bran has been boiled, with a little salts of tartar and alumn, rubbing gently between the hands when the heat will admit of it. When the water is cold, renew the application till any discoloration is removed, rinse in lukewarm water; lay them on white paper in a dark place to cool.

Pictures.—Wash with a sponge or a soft leather and water, and dry by rubbing with a silk handkerchief. When the picture is very dirty, take it out of its frame, procure a clean towel, and making it quite wet, lay it on the face of the picture, sprinkling it from time to time with clear soft water ; let it remain wet for two or three days ; take the cloth off and renew it with a fresh one ; after wiping the picture with a clean wet sponge, repeat the process till all the dirt is soaked out ; then wash it well with a soft sponge, and let it quite dry ; rub it with some clear nut or linseed oil. Spirits of wine and turpentine may be used to dissolve the hard old varnish, but they will attack the paint as well as the varnish if the further action of the spirits is not stopped at the proper time by using water freely.

Plate.— Take an ounce each of cream of tartar, muriate of soda, and alum, and boil in a gallon or more of water. After the plate is taken out and rubbed dry, it puts on a beautiful silvery whiteness. Powdered magnesia may be used dry for articles slightly tarnished, but if very dirty it must be used first wet and then dry.

Silver.—(*a*) Prepared chalk, 8 oz. ; turpentine, 2 oz. ; alcohol, 1 oz. ; spirits of camphor, 4 dr. ; liquor of ammonia, 2 dr. Apply with a sponge and allow to dry before polishing.

(*b*) Use a solution of cyanide of potassium, 12 oz. cyanide to 1 quart water ; immerse the silver, brush it with a stiff brush until clean, wash and dry.

Steel.—Unslaked lime is a capital thing to clean steel articles with. If steel ear-rings, brooches, &c., are kept in powdered quicklime, they suffer very little from rust. They should be carefully cleaned when put away, to remove any moisture that may have collected on them by handling.

To clean swords, &c., rub them with powdered brick-dust and oil, rub dry with brick-dust, polish with crocus and leather. (See also ii. 123.)

Crayons.

Crayons consist essentially of a white paste as a basis, which is made in one of the following ways :—

(*a*) Washed pipe-clay and washed chalk equal parts; mix them into a paste with sweet ale made hot, and with a chip or two of isinglass dissolved in it.

(*b*) Take the finest powder of calcined oyster-shells, sifted through muslin; mix it up with water in which a little rice and a little white sugar-candy have been boiled; according to the quantity of rice, so will be the hardness of the crayon. The quantity of sugar-candy should not be more than the size of a filbert-nut to a pint of water.

(*c*) Take common pipe-clay in powder, mix it up into a paste with very strong soapsuds, made thus :—Cut up 1 oz. of white soap into small shavings; dissolve it over the fire in ½ pint of water; stir into the mixture while hot the powdered pipe-clay as long as you can stir it. Spirits of wine added before the powders to render the soap-water transparent, is an improvement.

(*d*) Dissolve 3 oz. of spermaceti in 1 pint of water, stir into it a quantity of fine-sifted or washed white colour till of a proper consistence. If to be mixed with dark powders, a very little ox-gall is an improvement.

(*e*) Melt 3 oz. of shellac in 2 oz. of spirits of wine; this will form a thick liquid; to this add 6 parts of pipe-clay and 1 part of oil of turpentine; grind all well together. The lighter the colour of the shellac the better; also if colours are to be added they should be ground up with the turpentine, before this is added to the rest.

The great object of attention is to procure the white chalk or pipe-clay without grit. To accomplish this, take a large vessel of water put the whiting into it and mix well, pour off the top into another vessel, and throw the gritty sediment away; repeat several times. When this is done, let the whiting settle, and then pour the water from it and dry it for use.

The compositions for white crayons and the requisite colours being prepared, and that chosen made up into a stiff paste, it is to be placed upon a smooth slab of marble slightly oiled. The paste is rolled out with a rolling pin, then cut into slips, and these are rolled into cylinders by the aid of a little flat piece of wood, then cut to the length of 3 inches each, and placed in a slow oven or drying stove to become hard.

Instead of rolling the composition, it may be forced through the nozzle of a tin funnel, this is better for the delicate colours than rolling them; when dry they may be pointed.

It will always happen that except in black or white crayons, the colour alters very much in drying, so that in mixing an allowance must be made for this effect.

Black.—Chalk or charcoal is first to be sawn into 3-inch lengths, free from knots; then saw them longitudinally in narrow strips. Procure a tin trough about 4 inches by 3, and partly fill it with white wax; this being properly melted, the pieces of charcoal are to be saturated for forty-eight hours, and after draining they are fit for use. When white paste is employed, the only powdered colour to be used is lampblack, all the others are apt to get mouldy.

Blue. — A good soluble colour is Prussian blue, but it is hard to grind. Dissolve it in water, then put the solution in a hole cut in a piece of chalk, this will absorb the water, and leave a great portion of the colour ready for mixing. Blue verditer is a good bright colour, but is so gritty as to require washing, as recommended for whiting. The same may be said of smalts or cobalt.

Browns.—These are Cologne earth; umber, raw and burnt; sienna, raw and burnt; treated as the blue.

Carmine and Lake.—Crayons of these

colours are generally hard; when made with powdered colours, the proper way of mixing is to dissolve the colour first in water or spirits of wine, and add it to nearly-dry white colour, grinding the whole well together. There should be four or five shades. Madder is not used.

Greens.—These may be either simple colours, as emerald green, Prussian green, green carbonate of copper; or better formed by adding the compositions of the yellow and blue crayons together. Raw and burnt sienna may also be used in combination with Prussian blue or indigo. Good green crayons are more difficult to make than those of any other colour.

Mixed Colours.—Mixed or half colours are produced by an admixture of the colours required in the paste. Thus a combination of blue and carmine produces a purple; the yellows and red united form orange; black and carmine is a beautiful tint for shading; vermilion and black form a fine rich brown; green and brown form an olive colour; and red and brown a chocolate.

Vermilion and Red Lead, Red Ochre, Indian Red.—Each of these may be well ground in water, and when wet, mixed well with the white in different shades. These will make various reds, as well as salmon colour, flesh colour, or orange. Hematite or crocus, of itself, ground and mixed with a little size, forms an excellent crayon.

The square chalks, or crayons, are made of the mineral red chalk, or ochre, cut into slips with a saw. The same material is used in pencils for carpenters and others.

White.—The best whites to employ are whiting or prepared chalk, pipeclay, alum white or alumina, oyster-shell white, calcined bones, &c.

Yellows.—Dissolve the colours, which are Naples yellow, King's yellow, and yellow lake, in spirits of wine, and mix as for carmine. The chrome yellows are not so useful, because less durable. Gamboge, Indian yellow, and gall stone are not employed, but the various yellow ochres make good crayons.

CRAYONS FOR DRAWING ON GLASS.—Melt together equal quantities of asphaltum and yellow wax; add lamp-black, and pour the mixture into moulds for crayons. The glass should be well wiped with leather, and in drawing be careful not to soil the glass with the fingers. In trimming these crayons, if the edge be bevelled, like scissors, the point may easily be rendered very fine.

DRAWINGS.

(v. 22, 28.)

Drawing Paper.—The following table contains the dimensions of every description of English drawing-paper.

	inches.		inches.
Demy	20	by	15
Medium	22	,,	17
Royal	24	,,	19
Imperial	31	,,	21
Elephant	27	,,	23
Columbier	34	,,	23
Atlas	33	,,	26
Double Elephant ..	40	,,	26
Antiquarian	52	,,	29
Emperor	68	,,	48

For making detail drawings an inferior paper is used, termed "cartridge"; this answers for line drawings, but it will not take colours or tints perfectly. Continuous cartridge paper is also much used for full-sized mechanical details, and some other purposes. It is made uniformly 53 inches wide, and may be had of any length by the yard, up to 300 yards.

For plans of considerable size, mounted paper is used, or occasionally the drawings are afterwards mounted on canvas or linen.

Mounting Drawings or Paper on Linen.—The linen or calico is first stretched by tacking it tightly on a frame or board. It is then thoroughly coated with strong size, and left until nearly dry. The sheet of paper to be mounted requires to be well covered with paste; this will be best if done twice, leaving the first coat about ten minutes to soak into the paper. After applying the second coat place the paper on the linen, and dab it all over with a clean cloth. Cut off when thoroughly dry. (See also v. 28.)

Fastening Paper on a Drawing Board.—The stretched irregular edges of the sheet of paper are cut off against a flat ruler, squaring it at the same time. The sheet of paper is laid upon the board the *reverse* side upwards to that upon which the drawing is to be made. It is then damped over, first by passing a moist clean sponge, or wide brush, round the *edges* of the paper about an inch and a half on, and afterwards thoroughly damping the whole surface except the edges. Other plans of damping answer equally well; it is only necessary to observe that the edges of the paper should not be quite so damp as the other part of the surface. After the paper is thoroughly damped, it is left until the wet gloss entirely disappears; it is then turned over and put in its position on the board. About half an inch of the edge of the paper is then turned up against a flat ruler, and a glue-brush with hot glue is passed between the turned-up edge and the board; the ruler is then drawn over the glued edge and pressed along. If upon removing the ruler the paper is found not to be thoroughly close, a paper-knife or similar article passed over it will secure perfect contact. The next *adjoining edge* must be treated in like manner, and so on each consecutive edge, until all be secured. The contraction of the paper in drying should leave the surface quite flat and solid.

Cutting Pencils.—If the point is intended for sketching, it is cut equally from all sides, to produce a perfectly acute cone. If this be used for line drawing, the tip will be easily broken, or otherwise it soon wears thick; thus, it is much better for line drawing to have a thin flat point. The general manner of proceeding is, first, to cut the pencil, from two sides only, with a long slope, so as to produce a kind of chisel-end, and afterwards to cut the other sides away only sufficient to be able to round the first edge a little. A point cut in the manner described may be kept in good order for some time by pointing the lead upon a small piece of fine sandstone or fine glass-paper; this will be less trouble than the continual application of the knife, which is always liable to break the extreme edge.

Erasing Errors.—To erase English lead-pencil marks, native or bottle rubber answers perfectly. This, however, will not entirely erase any kind of German or other manufactured pencil marks. What is found best for this purpose is fine vulcanised rubber; this, besides being a more powerful eraser, has also the quality of keeping clean, as it frets away with the friction of rubbing, and presents a continually renewed surface to the drawing; the worn-off particles produce a kind of dust, easily swept away. Vulcanised rubber is also extremely useful for cleaning off drawings, as it will remove any ordinary stain.

For erasing ink lines, the point of a penknife or erasing knife is commonly used. A much better means is to employ a piece of fine glass-paper, folded several times, until it presents a round edge; this leaves the surface of the paper in much better order to draw upon than when erasures are made by a knife. Fine size applied with a brush will be found convenient to prevent colour running.

To produce finished drawings, it is necessary that no portion should be erased, otherwise the colour applied will be unequal in tone; thus, when highly-finished mechanical drawings are required, it is usual to draw an original and to copy it, as mistakes are almost certain to occur in delineating any new machine. Where sufficient time cannot be given to draw and copy, a very good way is to take the surface off the paper with fine glass-paper before commencing the drawing; if this be done, the colour will flow equally over any erasure it may be necessary to make afterwards.

Where ink lines are a little over the intended mark, and it is difficult to erase them without disfiguring other portions of the drawing, a little Chinese white or flake-white, mixed rather dry, may be applied with a fine sable brush; this will render a small defect much less perceptible than by erasure.

Whenever the surface of the paper is roughened by using the erasing knife, it should be rubbed down with some hard and perfectly clean rounded instrument.

Buying Drawing Instruments.—Persons with limited means will find it better to procure good instruments separately of a respectable maker, Stanley or Harling for instance, as they may be able to afford them, than to purchase a complete set of *inferior* instruments in a case. With an idea of economy, some will purchase second-hand instruments, which generally leads to disappointment, from the fact that inferior instruments are manufactured upon a large scale purposely to be sold as second-hand to purchasers, principally from the country, who are frequently both unacquainted with the workmanship of the instruments and with the system practised.

Inferior instruments will never wear satisfactorily, whereas those well made improve by use, and attain a peculiar working smoothness. The extra cost of purchasing the case and the nearly useless rules, would, in many instances, be equal to the difference between a good and an inferior set of instruments without the case. Instruments may be carefully preserved by merely rolling them up in a piece of wash leather, leaving space between them that they may not rub each other; or, what is better, having some loops sewn on the leather to slip each instrument separately under.

Drawing Board.—The qualities a good drawing board should possess are: an equal surface, which should be slightly rounded from the edges to the centre, in order that the drawing paper when stretched upon it may present a solid surface; and the edges perfectly straight, and at right angles to each other.

Using a Drawing Pen.—It should be held very nearly upright, between the thumb and first and second fingers, the knuckles being bent, so that it may be held at right angles with the length of the hand. The handle should incline only a very little —say ten degrees. No ink should be used except Indian ink, rubbed up fresh every day upon a clean palette. Liquid ink and other similar preparations are generally failures. The ink should be moderately thick, so that the pen when slightly shaken will retain it a fifth of an inch up the nibs. The pen is supplied by breathing between the nibs before immersion in the ink, or by means of a small camel-hair brush; the nibs will afterwards require to be wiped, to prevent the ink going upon the edge of the instrument to be drawn against. The edge used to direct the pen should in no instance be of less than a sixteenth of an inch in thickness; a fourteenth of an inch is perhaps the best. If the edge be very thin, it is almost impossible to prevent the ink escaping upon it, with the great risk of its getting on to the drawing. Before putting the pen away, it should be carefully wiped between the nibs by drawing a piece of folded paper through them until they are dry and clean.

Testing the Accuracy of a Straight-edge.—Lay the straight-edge upon a stretched sheet of paper, placing weights upon it to hold it firmly; then draw a line against the edge with a needle in a holder, or a very fine hard pencil, held constantly vertical, or at one angle to the paper, being careful to use as slight pressure as possible. If the straight-edge be then turned over to the reverse side of the line, and a second line be produced in a similar manner to the first at about the twentieth of an inch distance from it, any inequalities in the edge will appear by the differences of the distances in various parts of the lines, which may be measured by spring dividers.

Another method will be found to answer well if three straight-edges are at hand; this method is used in making the straight-edge. Two straight-edges are laid together upon a flat surface, and the meeting edges are examined to see if they touch in all parts, reversing them in every possible way. If these two appear perfect, a third straight-edge is applied to each of the edges already tested, and if they touch it in all parts the edges are all perfect. It may be observed that the first two examined, although they touch perfectly, may be regular curves; but if so, the third edge applied will detect the curvature.

Using the Plain Parallel Rule.—One of the rules is pressed down firmly with the fingers, while the other is moved by the centre stud to the distances at which parallel lines are required. Should the bars not extend a sufficient distance for a required parallel line, one rule is held firmly, and the other is shifted, alternately, until the distance is reached.

Using Dividers or Compasses.—It is considered best to place the forefinger upon the head, and to move the legs with the second finger and thumb. In dividing distances into equal parts, it is best to hold the dividers as much as possible by the head joint, after they are set to the required dimensions; as by touching the legs they are liable to change, if the joint moves softly as it should. In dividing a line, it is better to move the dividers alternately above and below the line from each point of division, than to roll them over continually in one direction, as it saves the shifting of the fingers on the head of the dividers. In taking off distances with dividers, it is always better, first to open them a little too wide, and afterwards close them to the point required, than to set them by opening.

Pencilling.—If a drawing could be at once placed to the best advantage on the paper, and surely made without mistake and with all its lines correctly limited when first drawn, it might be made in ink directly on the blank paper. To avoid the errors inevitable in the first copy of any production, even when made by those most practised, drawings are first pencilled and then inked. The whole theory of pencilling, then, is to lay out correct *tracks* on which the pen is to move, leaving the mind, during the inking, free from all thought of *accuracy* of the *construction*, that it may be given to *excellence* in *execution*. Therefore, the whole of the pencil-construction should be *most accurately* made in the *finest faint* lines with *a hard* pencil.

Finishing a Drawing.—While "Finish a drawing without any error or defect," should be the draughtsman's best motto, he should never be in haste to reject a damaged drawing, but should exercise his ingenuity to see how far injuries done to it may be remedied. "Never lose a drawing once begun," should be his second motto; and since prevention is easier and better than cure, let him always work calmly, inspect all instruments, hands, and sleeves, that may touch a drawing, before commencing an operation; let the paper, instruments, and person *be kept clean*, and when considerable time is to be spent upon a portion of the paper, let the remainder be covered with waste paper, pasted to one edge of the board.

For the final cleaning of the drawing, stale bread, or the old-fashioned black rubber, if not sticky, is good; but, aside from the carelessness of ever allowing a drawing to get very dirty, any fine drawing will be injured, more or less, by *any* means of removing a considerable quantity of dirt from it.

Another excellent means of preventing injuries, which should be adopted when the drawing is worked upon only at intervals, is to enclose the board, when not in use, in a bag of enamelled cloth or other fine material.

Lettering.—The title to a drawing should answer distinctly the four questions — *What*, *Who*, *Where*, and *When*— *What*, including the use and scale; *Who*, both as to designer or inventor, and draughtsman; *Where*, both as to the place, institution, or office where the drawing was made, and the locality of the object drawn; and *When*.

If the drawing is perfectly symmetrical, its title should have the same axis of symmetry as the drawing. If the drawing is unsymmetrical, the title may be at either of the lower corners.

These principles do not apply to horizontal views, as maps of surveys, when the title may be wherever the shape of the plot affords the best place.

One quite essential element of beauty in a title is its arrangement, or the *form of its outline* as a whole. It should embrace such variations in the length of its line of letters that the curve formed by joining the extremities of those lines would be a simple and graceful one, having also a marked variety of form. Also the greatest length of the title should generally be horizontal; or its proportions, as a whole, like those of the border of the drawing.

When the occupation of the paper affords only narrow blank spaces lying lengthwise of the paper, the title looks well mostly on a single line at the bottom, the principal words being in the middle, and the subordinate ones at the two sides.

Moreover, horizontal lines should prevail in the direction of the lines of words in the title. Indeed, the title may be arranged wholly on horizontal lines with good effect, though an arched or bow-shaped curve for the principal words may be adopted when the drawing includes some conspicuous arching lines.

The size of the title should be appropriate to that of the drawing. In particular, the rule has been proposed that the height of the largest letters in the title should not exceed three-hundredths of the shorter side of the border. Also, the relative size of the different portions of the title should correspond to their relative importance, the name of the object and its inventor being largest, and that of the draughtsman, his location, and the date of his work being considerably smaller.

Geometrical drawings are *most* appropriately lettered with geometrical letters, which, when neatly made, always look well. Any letters, however, having any kind of sharply-defined and precise form, as German text, are not inappropriate to a geometrical drawing; but vaguely formed "rustic" or other freehand letters are in bad taste on such drawings.

Letters should correspond in conspicuousness or body of colour with the rest of the drawing, not being obtrusive from great heaviness of solid black outline, nor unobservable from excessive faintness. Also, violent contrasts of heaviness among neighbouring portions of the title should be avoided; though there may be a gradual change, both of intensity and size, from the most to the least important words of the title.

This should, first of all, not exceed in elaborateness the draughtsman's ability to execute it with perfect neatness and clearness. Then it should agree with the character of the drawing. Plain and simple letters look best on a similar drawing, while a complicated and highly-finished drawing may receive letters of more ornamental character.

Borders.—For line drawings, the border should be a geometrical design, in lines, with curved or angular corners, or with combinations of straight or curved lines, forming geometrical corner-pieces. These borders may vary in complexity from a rectangular border in single lines to borders which, though geometrical, may be elaborate and elegant. Thus: a plate of varieties of straight horizontal lines may have a plain rectangular border; one including oblique lines may include oblique lines in the border, either as a little tuft in each corner, a truncated corner, or a square set diagonally, &c. Plates embracing curve lines may have quarter-circle borders, either convex or concave inwards—of which the former have most decision. Such plates may also have little circles for corner-pieces. Borders may sometimes conform in a pleasing manner to the general outline of a drawing. Thus, an arched bridge may have a semi-oval upper border and a square-cornered border at the base of the drawing; and an ornamental device may crown the summit of the border.

When the drawing is a shaded one, containing, therefore, some free-hand work, the border may be partly free-hand also; but should still be largely geometrical in its design, and should represent a real border of substantial materials, corresponding to the subject of the drawing. Thus, the mouldings and ornaments should represent ornamental metallic castings, carvings in wood, mouldings in plaster, or scrolls and leaves of rolled metal; but garlands, tassels, and tendrils, &c., should not be introduced.

The border to a geometrical drawing should be like the drawing itself in being executed with the drawing pen and brush, as well as with the mapping pen. Free-hand pen borders, representing the products of the soil, with cornucopias, little pen sketches of scenery, or similar agricultural or landscape devices, worked in as corner-pieces, are more appropriate on topographical drawings.

As to colour, *primary* colours should not be largely introduced into the border; *first*, since they, when obtrusive, are adapted to ruder or less impressible tastes than the secondary hues, shades, and tints, which are more gratifying to delicate tastes; and *secondly*, from the impertinent conspicuousness which they may give to the border.

Drawings which are shaded only in sepia or ink, or any dark neutral tint, may have the border done in the same, or in a dark complementary colour. Tinted ink drawings are best finished with a plain ink border.

Indian Ink is used for producing the finished lines of all kinds of geometrical drawing. Being free from acid, it does not injure or corrode the steel points of the instruments. The genuine ink, as it is imported from China, varies considerably in quality; that which answers best for line drawing will wash up the least when other colours are passed over it. This quality is ascertained in the trade, but not with perfect certainty, by breaking off a small portion. If it be of the right quality it will show, when broken, a very bright and almost prismatic-coloured fracture. Indian ink should be used immediately after it is mixed; if re-dissolved it becomes cloudy and irregular in tone, but with every care, it will still wash up more or less. (See also ii. 335.)

Colours.—For colouring drawings, the most soluble, brilliant, and transparent water-colours are used; this particularly applies to plans and sections. The colour is not so much intended to represent that of the material to be used in the construction, as to clearly distinguish one material from another employed on the same work.

The following table shows the colours most employed by the profession:—

Carmine or Crimson Lake	For brickwork in plan or section to be executed.
Prussian Blue	Flintwork, lead, or parts of brickwork to be removed by alterations.
Venetian Red	Brickwork in elevation.
Violet Carmine	Granite.
Raw Sienna	English timber (not oak).
Burnt Sienna	Oak, teak.
Indian Yellow	Fir timber.
Indian Red	Mahogany.
Sepia	Concrete works, stone.
Burnt Umber	Clay, earth.
Payne's Grey	Cast iron, rough wrought iron.
Dark Cadmium	Gun metal.
Gamboge	Brass.
Indigo	Wrought iron (bright).
Indigo, with a little Lake	Steel, bright.
Hooker's Green	Meadow land.
Cobalt Blue	Sky effects.

And some few others occasionally for special purposes.

In colouring plans of estates, the colours that appear natural are mostly adopted, and may be produced by combining the above. Elevations and perspective drawings are also represented in natural colours, the primitive colours being mixed and varied by the judgment of the draughtsman, who, to produce the best effects, must be in some degree an artist.

Care should be taken in making an elaborate drawing, which is to receive colour, that the hand at no time rest upon the surface of the paper, as it is found to leave a greasiness difficult to remove. A piece of paper placed under the hand, and if the square is not very clean, under that also, will prevent this. Should the colours, from any cause, work greasily, a little prepared ox-gall may be dissolved in the water with which the colours are mixed, and will cause them to work freely.

Shading.—For shading, camel or sable hair brushes, called "softeners," are generally used: these have a brush at each end of the handle, one being much larger than the other. The manner of using the softener for shading is, to fill the smaller brush with colour, and to thoroughly moisten the larger one with water; the colour is then laid upon the drawing with the smaller brush, to represent the dark portion of the shade, and immediately after, while the colour is quite moist, the brush that is moistened with water is drawn down the edge intended to be shaded off; this brush is then wiped upon a cloth and drawn down the outer moist edge to remove the surplus water, which will leave the shade perfectly soft.

If very dark shades are required, this has to be repeated when the first is quite dry.

To tint large surfaces, a large camel-hair brush is used, termed a "wash-brush." The manner of proceeding is, first, to tilt the drawing, if practicable, and commence by putting the colour on from the upper left-hand corner of the surface, taking short strokes the width of the brush along the top edge of the space to be coloured, immediately following with another line of similar strokes into the moist edge of the first line, and so on as far as required, removing the last surplus colour with a nearly dry brush. The theory of the above is, that you may perfectly unite wet colour to a moist edge, although you cannot to a dry edge without showing the juncture. For tinting surfaces, it is well always to mix more than sufficient colour at first.

Colouring Tracings.—It is always best to colour tracings on the back, as the ink lines are liable to be obliterated when the colour is applied. Mix the colours very dark, so that they may appear of proper depth on the other side. If ink or colour does not run freely on tracing cloth, mix both with a little ox-gall.

Cutting Stencil Plates.—The perforations are made through the metal, either by engraving, by etching with nitric acid diluted with about one-third water, or, what is better, by both methods combined. If engraving only is employed, the force necessarily applied to the graver will sometimes stretch the plate unequally, whereas by etching alone, the edges of the perforations are left rough, and the corners imperfect; but if the line be lightly etched, and afterwards cleared with the graver, it may be rendered perfect without any risk of cockling the plate. If the back of the plate is smeared with a little oil, the cuttings will come out clean. A good ground for the etching of these plates is made by rubbing on them, slightly heated over a spirit-lamp, a cake of heel-ball.

Copper is much better than brass for stencil plates; the metal being softer, it lies closer to the paper upon receiving the pressure of the stencilling brush. This close contact is a very important consideration, as it prevents the hairs of the brush from getting under the plate, and producing rough edges.

Plain stencil alphabets will not be necessary to a draughtsman, if he is a good writer, as they will only save him a little time. A greater saving may be effected by the use of words which are constantly recurring; as Ground plan, Front elevation, Section; or of interiors, as Drawing-room, Kitchen.

For railway or public works, headings of plans may be cut in suitable character and style; also words which are frequently repeated on any particular works, as the name and address of the architect or engineer.

Besides letters and words, there are many devices by the use of which a superior effect may be produced, and much time saved; of these may be mentioned, north points, plates for the representation of surface of country, as plantation, wood, or marsh, corners and borders for finished plans, and many other devices.

Using Stencil Plates. — The brush requires to be squarely and equally cut, and to be kept moderately clean. If Indian ink is used, the largest surface of the cake should be taken to rub the moist brush upon, to get it equally diffused and softened with colour. A cheap kind of ink is sold with stencil plates, which answers better than Indian ink, as it runs less upon the drawing and presents a larger surface to the brush.

After the plate has been in use some time, the fine lines and corners become clogged with ink, which may easily be removed by soaking the plate a short time in warm water, and afterwards lightly brushing it upon a flat surface until quite clean. It must be particularly observed that a cloth should at no time be applied to the plate either to clean or to wipe it, as this would be almost certain to catch in some of the perforations, and probably spoil the plate.

If the plate by improper use becomes cockled, it may be flattened, if laid upon a hard flat surface, by drawing a cylindrical piece of metal, as, for instance, the plain part of the stem of a poker; firmly across it several times on each side of the plate.

In using the stencil plate, hold it firmly to the drawing by *one edge* only, in no instance allowing the fingers to cross to the opposite edge. The general method is, to place the fingers of the left hand along the bottom edge. When the brush is diffused with ink, so that it is just moist, lightly brush it upon a book-cover or pad, so as to free the points from any excess of colour. In applying the brush to the plate, it should be held quite upright, and moved, not too quickly, in small circles, using a constant, equal pressure, as light as appears necessary. The stencilling should be commenced at one end of the plate and proceeded with gradually to the other, moving onwards as the perforations appear filled with colour, being particularly careful not to shift the fingers placed upon the plate during the operation. If the plate is very long, after each word the fingers may be shifted, if the plate be held down during the time firmly by the other hand. Should there not be quite sufficient ink in the brush to complete the device, the plate may be breathed upon, which will moisten the ink attached to the plate. If, after the plate is removed, the device appears light in parts, the plate may be replaced and the defects remedied, if very great care be taken to observe that the previous stencilling perfectly covers the perforations.

In stencilling words or numbers with the separate letters of the alphabet, draw a line where the bottoms of the letters are intended to come, take the separate letters as required and place them upon the line, so that the line just appears in the perforations. That the letters may be upright, it is best that the next letter on the slip used should also allow the line to appear in it. The required distance of the letters apart must be judged of by the eye, a pencil mark being made, after each letter is completed, to appear in the perforation on the near side of the next letter to be stencilled.

With care, a stencil plate will last in constant use for many years; without care, it is practically spoilt by taking the first impression.

Removing Drawings from the Board.—Make a pencil line round the paper with the T-square at a sufficient distance to clear the glued edge, and to cut the paper with a penknife, guided by a stout ruler. In no instance should the edge of the T-square be used to cut by. A piece of hard wood, half an inch thick by two inches wide, and about the length of the paper, forms a useful rule for the purpose, and may be had at small cost. The instrument used for cutting off, in any important draughtsman's office, is what is termed a *stationers' rule*, which is a piece of hard wood of similar dimensions to that just described, but with the edges covered with brass. It is necessary to have the edge thick to prevent the point of the knife slipping over. Either of the above rules will also answer to turn the edge of the paper up against when glueing it to the board.

The Frame for a Drawing is to afford a suitable protection to the finished drawing, and hence should be so subordinate in design and colour as not to distract attention from the drawing.

For geometrical drawings, a gilt frame is, in general, preferable to a dark-coloured wooden one. Occasionally the latter style of frame may be appropriate, as in case of a very darkly-shaded drawing on tinted paper, or of a drawing which very completely fills the paper.

It hardly need be said that a frame of plain mouldings is more appropriate for a geometrical drawing than is a carved or stucco-moulded frame. For ordinary geometrical drawings, nothing is prettier than an Oxford frame of light oak, or a plain gold frame.

Vegetable Parchment is made by dipping ordinary paper, for a few seconds, into a solution, containing one part water to six sulphuric acid; then washing it carefully, to remove every trace of acid. (See also ii. 396.)

Indelible Pencil Writing.—(*a*) Lay the writing in a shallow dish, and pour skimmed milk upon it. Any spots not wet at first may have the milk placed upon them lightly with a feather. When the paper is wet all over with the milk, take it up and let the milk drain off, and remove with the feather the drops which collect on the lower edge. Dry carefully.

(*b*) Prepare water-starch, in the manner of the laundress, of such a strength as to form a jelly when cold, and then apply with a broad camel-hair brush, as in varnishing.

(*c*) The same may be done with thin, cold isinglass water or size, or rice water.

Mounting Engravings. — Strain thin calico on a frame, then carefully paste on the engraving so as to be free from creases; afterwards, when dry, give two coats of thin size (a piece the size of a small nut in a small cupful of hot water will be strong enough), finally, when dry, varnish with white hard varnish. (See also iv. 403, v. 28.)

Renewing Manuscripts. — Take a hair pencil and wash the part that has been effaced with a solution of prussiate of potash in water, and the writing will again appear if the paper has not been destroyed. (See also ii. 343, 392.)

Uniting Parchment to Paper, or Wood.—(*a*) The surface of the parchment must first be moistened with alcohol or brandy and pressed while still moist upon glue or paste. When two pieces of parchment are to be joined, both must be moistened in this way. It is said that the paper will sooner tear than separate where it has been thus fastened together.

(*b*) Another way is to put a thin piece of paper between the surfaces of parchment, and apply the paste. This forms a firm joint, and can with difficulty be separated. Glue and flour paste are best adapted for uniting surfaces of parchment.

Tracing Paper.—(*a*) Wash very thin paper with a mixture of: Spirits of turpentine, 6; rosin, 1; boiled nut oil, 1, parts by weight, applied with a soft sponge.

(*b*) Brush over one side of a good, thin, unsized paper with a varnish made of equal parts of Canada balsam and turpentine. If required to take water colour, it must be washed over with ox-gall and dried before being used.

(*c*) Open a quire of double-crown tissue paper, and brush the first sheet with a mixture of mastic varnish and oil of turpentine, equal parts; proceed with each sheet similarly, and dry them on lines by hanging them up singly. As the process goes on, the under sheets absorb a portion of the varnish, and require less than if single sheets were brushed separately.

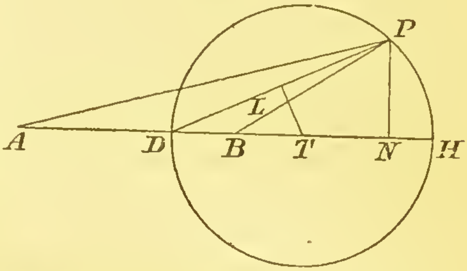
(*d*) Any kind of opaque drawing paper in ordinary use may be employed for this purpose, stretched in the usual way over the drawing to be copied or traced. Then, by the aid of a cotton pad, the paper is soaked with perfectly pure benzine. The pad causes the benzine to enter the pores of the paper, rendering the latter more transparent than the finest tracing paper. The most delicate lines and tints show through the paper so treated, and may be copied with the greatest ease, for pencil, Indian ink, or water-colours take equally well on the benzinised surface. The paper is neither creased nor torn, remaining whole and supple. Indeed, pencil marks and water-colour tinting last better upon paper treated in this way than on any other kind of tracing paper, the former being rather difficult to remove by rubber. When large drawings are to be dealt with, the benzine treatment is only applied in parts at a time, thus keeping pace with the rapidity of the advancement of the work. When the copy is completed, the benzine rapidly evaporates, and the paper resumes its original white and opaque appearance without betraying the faintest trace of the benzine. If it is desired to fix lead-pencil marks on ordinary drawing or tracing paper, this may be done by wetting it with milk and drying in the air.

Transfer Paper is made by rubbing white paper with a composition consisting of 2 oz. of tallow, $\frac{1}{2}$ oz. powdered black-lead, $\frac{1}{4}$ pint of linseed oil, and sufficient lampblack to make it of the consistency of cream. These should be melted together and rubbed on the paper whilst hot. When dry it will be fit for use.

Copying Drawings to a Reduced Scale.—Following are methods of copying a drawing to a scale $\frac{1}{m}$th of the original scale by means of an easily-constructed geometrical diagram, which may be found useful to mechanical and architectural draughtsmen—at any rate, in the absence of proportional compasses. Indeed, when m is less than 3, working with a diagram is at least as easy as working with the clumsy instrument just named, and the results are as accurate, supposing the diagram to be carefully constructed.

(*a*) In Fig. 1, let A and B be fixed points in a piece of cardboard or thick drawing paper, and A P, B P, any two lines drawn from them and meeting in P. Then, if in all cases A P = m . B P, the locus of P is a circle whose centre (T) is on A B produced.

Fig. 1.



To prove this, draw P N perpendicular to A B, or A B produced. Let B N = x, N P = y, and consider the length of A B (the *base*) as representing unity. Then—

$$y^2 + (x + 1)^2 = m^2 (y^2 + x^2)$$

from which we derive—

$$y^2 + \left(x - \frac{1}{m^2 - 1}\right)^2 = \frac{m^2}{(m^2 - 1)^2}.$$

This is the equation to a circle. B T = $\frac{1}{m^2 - 1}$, and the radius T P = $\frac{m}{m^2 - 1}$. By giving to m different values, we can calculate the corresponding values of B T and T P. Thus, if $m = \frac{\sqrt{3}}{\sqrt{2}}$, which is the ratio used in isometric projection, it will be found that B T = 2, and T B = 2·45. If $m = \frac{3}{2}$, B T = 0·8, and T P = 1·2. If $m = 2$, B T = 0·33, and T P = 0·67, &c. The difference between the shortest length, A D, that can be taken on the original drawing and A H, the longest, decreases as we increase m, and it is easily shown that the range of the instrument, in its most simple form, is expressed by the formula—

$$A\,H = \frac{m+1}{m-1} .\ A\,D.$$

In practice it is rarely necessary to calculate numerically the lengths B T and T P, for by a simple geometrical construction we are enabled to produce a diagram to any ratio m, given two lines whose lengths are in that ratio. Thus, suppose A B to be a suitable length for the base, and A P to equal m. B P. Bisect the angle A P B by the line P D. Then, since, by Euclid VI. 3,

$$A\,D : D\,B :: A\,P : B\,P$$
$$\therefore A\,D : D\,B :: \ m : \ 1,$$

which shows that P D is a chord of the required circle. Bisect P D in L, and draw L T perpendicular to P D. Evidently T, since it lies on both L T and A H, must be the centre, T P being the radius. Describe the circle, and the diagram is complete.

The mode of using the diagram requires little explanation. A length A P, from the original drawing, being set off with ordinary compasses from A, determines the position of the point P, and we take P B for the corresponding length in our copy. To prevent their being holed by compass points, A and B ought to be protected by horn centres.

For any measurement shorter than A D, when it cannot be taken indirectly (that is, as the difference between two longer measurements), a supplementary circle, constructed to a shorter base than A B, is required. In the diagram, Fig. 2, from A draw any line, A h = A D, the shortest of the measurements; join H h, and through T, B, and D draw lines parallel to H h, meeting A h in t, b, and d respectively. Then, A b is the new base, and t the centre of its circle, of which the radius is t d. Supposing A B to be of sufficient length, a third circle and base can be derived from the second, a fourth from the third, and so on; and it is easy to see—since the two circles in the figure are tangential to the arc f D h, described from A as a centre with the radius A D—that any measurement found on one circle cannot be found on any other, and therefore that no doubt need occur as to which base a measurement applies to. When there are but two circles and bases, as in Fig. 2, since A h = A D, we have

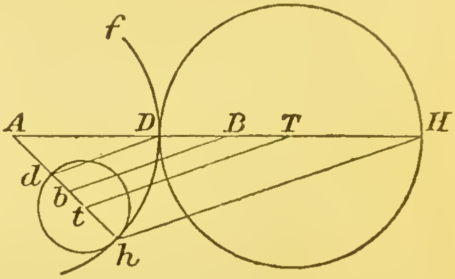
$$A\,D = \frac{m+1}{m-1} .\ A\,d,$$

and

$$A\,H = \frac{m+1}{m-1} .\ A\,D,$$

$$\therefore\ A\,H = \left(\frac{m+1}{m-1}\right)^2 .\ A\,d.$$

Fig. 2.



In practice more than two circles are rarely required; but if we had n circles, and l and s were the greatest and least measurements within the range of the instruments, then—

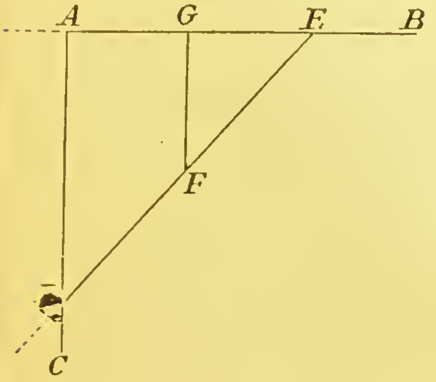
$$l = \left(\frac{m+1}{m-1}\right)^n .\ \ s.$$

(b) Suppose that the drawing is to be reduced to three-fourths, draw a straight line A B (Fig. 3) of any length. From any point A drop a perpendicular A C at right angles to A B. Lay off on A C a convenient distance A D. Then with D as a centre and radius of a length of which A D is three-fourths the original drawing, cut A B in E, join D E and the diagram is completed.

If any dimension E F from the original drawing is with compasses applied from E along E D, then F G will be the reduced dimension.

It is not necessary in practice to draw the line F G, as, by oscillating the point of the compasses, the point of perfect contact will be easily got, and will be the required reduction. The lines A B and D E may be produced in the direction of the dotted lines, thereby enabling the draughtsman to measure longer distances than that for which the diagram was at first constructed, should occasion require.

Fig. 3.



DYEING.

(ii. 206.)

Though great changes have taken place in the dyeing industry owing to the introduction of the coal tar dyes, nevertheless in many places these are not procurable, and therefore the old-fashioned colouring matters are not by any means superseded in out-of-the-way places, and the old-fashioned recipes are still acceptable. For newer systems, the reader is referred to the Second Series, p. 206 *et seq.*, and to Spon's 'Encyclopædia.'

Mordants, &c.—*Ageing Liquor.*—20 lb. caustic soda at 60° Tw., 20 lb. white arsenic in powder. Boil until all the arsenic is dissolved. Make a solution of 3 lb. of chlorate of potash in 4 gal. of water; add the first liquor until it stands at 28° Tw.

Black Liquor.—300 lb. copperas dissolved with 175 gal. hot water, then add 57 gal. acetate of lime liquor at 16° Tw., or 32 lb. copperas, 5 quarts pyroligneous acid at 7° Tw., 10 gal. acetate of lime liquor at 24° Tw. Used as a mordant; gives black with madder at 6° Tw.; very diluted gives various shades of violet, and with red liquor gives chocolate.

Pink Mordant.—(*a*) *Alkaline.*—To 10 gal. caustic potash add slowly 35 lb. sulphate of alumina; thicken with British gum, and fix with chloride of zinc or sal ammoniac.

(*b*) *Verdigris.*—2 quarts water at 160° F., 2 lb. white sugar of lead, 2 lb. sulphate of copper. Used in calico printing, and in the black dye for silk.

Red Mordant.—(*a*) 20 lb. powdered alum is dissolved in 9 gal. water heated to 140° F.; mix with this 20 lb. sugar of lead, and add 2 lb. soda crystals; should be frequently stirred for days. Used in the above proportions for calico.

(*b*) *For Madder Pink.*—8 lb. alum, 9 quarts water, 6 lb. sugar of lead. For lighter pink, use 10 gal. water, 37 lb. alum, 15 lb. sugar of lead, 2½ lb. pulverised chalk, 5 lb. chloride of sodium (common salt).

Cotton. BLACK.—(*a*) For 40 lb. Boil or scald 10 lb. sumach; lay the cloth or yarn in this for 18 hours; wring out; run through acetate of iron, 40° Tw.; 4 turns, or for half an hour; wring out; repeat and wash well in 3 waters; then boil 8 lb. logwood and 1 lb. fustic; put off the boil and enter; or the clear of the liquor may be decanted into another dish; 1 run, continue half an hour; wring out; repeat; sadden with 1 lb. copperas; 2 runs; wash and dry. In job dyeing, for a piece of cloth 20 yards, prepare in strong hot sumach like the above; then put 3 quarts slaked lime into 20 gallons water; when the lime precipitates, decant the clear into another tub, lift the cloth out of the sumach, give 1 run through acetate of iron, 1 through lime, repeat in the iron, and again through the lime. Should the cloth have got unlevel, give an extra run through the lime to make it level; then wash in 2 waters, and give logwood and a little fustic, like the above.

(*b*) For 50 lb. Dark blue on blue vat; lay them in 18 lb. hot sumach for 24 hours; lift, and sadden with black iron liquor; wash and dry.

Blue Vat.—140 gal. water, 16 lb. copperas, 8 lb. ground indigo, 16 lb. quicklime. Rake up occasionally for 5 or 6 hours, till all the copperas be dissolved; if the vat be of a greenish yellow colour, consider it in good order; if it assumes a dark green colour, it shows a deficiency of lime; if yellowish, it is short of copperas; after raking, allow 12 hours to settle before working; renovate with copperas and lime, according to the state of the vat.

Blue, Deep.—Put 10 lb. cotton through the blue vat; soak in a decoction of 2 lb. sumach for 3 hours; work for 15 minutes through water containing 1 pint red mordant and 1 pint black liquor; wash twice in hot water, then work 20 minutes in a decoction of 2 lb. logwood; lift, and raise with ½ pint of red mordant, work 10 minutes; wash and dry.

Blue, Pale.—For 50 lb. 2½ lb. prussiate of potash; nitrate of iron, 3° Tw.; add 2½ lb. crystals of tin, 1 pint vitriol. Turn in the iron tub 20 minutes; lift; run through cold water (not rinsed), wring up: shake well out; dissolve the prussiate into 100 gallons water; enter, and winch 15 minutes; lift, and give 2 gills vitriol; return for 10 minutes; lift, and run through water; again through the iron tub; repeat in the prussiate; raise again with vitriol, and when the required shade is got, lift; 1 water, and finish out of a weak solution of alum.

Blue, Royal.—Run upon the cold blue vat; air out; wash in 2 waters, and sour; then give a run through the iron (nitrate) tub; 1 water, and top with prussiate of potash, ½ oz. to the pound of yarn. If the vat is not in good order, or without that convenience, better do this colour with prussiate altogether.

Blue, Woad Vat.—250 gallons water, 170° F., put in 150 lb. best English woad, well chopped; 9 lb. best indigo, well ground; 2½ lb. madder; 2½ lb. bran. Rake all together well up, and the vat ought to assume a green appearance; in 12 or 14 hours, dip a piece of cloth, or a little wool, into the vat; if it dye green, it will turn blue by exposure to the air; rake up, and if it holds the head well up, put in 1 quart of quicklime, and rake again; in 3 hours after, rake again, and if it looks of a greenish yellow, put in 1½ quart more of lime; in 3 or 4 hours after, rake again; if the vat looks yellower, use another quart of lime; in an hour after this, if it smells slightly of lime, it has enough; if it smells strongly of lime, it has too much, which may be counteracted by using 1½ or 2 lb. of madder, or by heating the vat; when the liquor is hard, it is of an orange colour, which may be seen by blowing; when it is soft, it appears faint yellow, and throws up a scum. In serving or heating the vat, it should be raked occasionally, taking care not to disturb the sediment, but merely to bring the liquor to an equal degree of heat; then put in 3 lb. indigo, and 1½ lb. madder; allow it to settle for 12 hours; then, if it looks of a greenish colour, and does not smell of lime, use 1 quart of lime. In all cases, if the vat smells slightly of lime, it is a proof that it has enough; if it smells very strongly of lime, give 1½ lb. of potash, and 2 lb. madder: then, if it smells of lime instead of woad, cool by taking off the covering, and a considerable quantity of the lime will evaporate: heat up again, and put in 30 or 35 lb. of woad; when hot, rake well up; look at the vat in 6 or 8 hours, if the upper part of the liquor looks yellow, rake up, and if it does not darken, use 2 quarts of lime; when you rake up, stir the bottom at all times, except when heating up; 3 hours is long enough for a woad vat to settle. In dyeing cotton or silk on this vat, it is safest to work it cold, or at most lukewarm.

Brown.—For 50 lb. or 200 yards. Prepare with 2½ lb. sumach, acetate of iron, 2° Tw., and lime, 1° Tw. Dye with 18 lb. redwood and 4 lb. fustic; 24 hours in the sumach, lift, and run through the iron tub, then through the lime; repeat in each tub, and wash in 3 waters; then scald or boil the wood; decant into another tub; enter and winch for 20 minutes; air out, and repeat; if not dark enough, add a little logwood; then sadden with 6 or 8 oz. copperas.

Brown, Madder.—For 40 lb. Boil or scald 10 lb. sumach; lay the goods in it for 24 hours; lift, and decant into a tub, containing 60 gallons water, 1 quart acetate of iron, and 1 quart mordant. Enter; turn for half an hour; lift, and wash in 2 waters; then dye with 10 lb. best crop madder; enter cold, and bring to the spring.

Brown, Dark, with Catechu.—For 200 yards. Boil 30 lb. catechu; enter the cloth as it leaves the singeing-work; winch it in the catechu for some time, and let it down into the boiler all night; in the morning light a fire under the boiler; lift the cloth, and give 2 runs through acetate of iron; wash well out of the iron; have the boiler up, and give another run through it at the boil, 1 hour; lift, and give other 2 runs of iron, when it will be quite black; stripe with lime to the shade required.

Brown, Light Catechu.—For 50 lb. Boil 20 lb. catechu in one boiler, 5 lb. chrome in another. Enter in the catechu first; work 20 minutes, and wring out; then through the chrome, 10 minutes, and wring out; though catechu again; giving shot about till dark enough; finishing with catechu.

Drab.—For 40 lb. Boil 6 lb. fustic; scald 2½ lb. limawood; 2 lb. sumach. Decant into a wooden vessel, capable of containing 100 gallons; reduce with cold water to handling heat; enter; 6 turns; wring out; sadden with 8 oz. copperas; 4 turns; wring out again, and give 4 oz. bluestone.

Fawn.—For 50 lb. Boil 5 lb. fustic and 3 lb. limawood. Add 2 lb. alum. Decant the fustic and limawood into a large tub; reduce to handling heat; enter and work 15 minutes; if not dark enough, add 8 oz. logwood; then wash and dry.

Green.—For 40 lb. Preparation, nitrate of iron, 4° Tw. Dyeing 1½ lb. prussiate of potash, 45 lb. fustic, 8 oz. extract of indigo. Raising, 1 pint vitriol, 5 lb. alum. Turn in an iron tub for 20 minutes; wring out; run through cold water lightly, wring and shake well out; dissolve the prussiate; put it into a tub of cold water, 4 or 5 turns; lift, and give 2 gills sulphuric acid; 4 or 5 turns more; run through cold water, and wring out; repeat in the iron and prussiate tubs as before dyeing; give the fustic moderately warm in a clean liquor; turn 30 minutes; lift, and raise in the same liquor with 5 lb. alum and 6 oz. extract of indigo; winch in this till you get the required shade.

Green, Fast Chrome.—For 50 lb. 10½ lb. chrome, 5 lb. acetate of lead. Blue on the blue vat; wash in 2 waters, and give a warm sour; then dissolve and put the lead and chrome into separate tubs; enter in the lead tub first; wring out; then through the chrome; continue from the one to the other till dark enough.

Lavender.—100 yards. Scald 1 lb. logwood and 2 lb. sumach. Decant both into a tub of sufficient size; cool to 150° F.; add 2 gills vitriol; winch in this 20 minutes; lift and run slightly through acetate of iron; wash in 2 waters, then give 1 lb. logwood as before; raise with a pint of muriate of tin; wash in 2 waters; then, in a tub of cold water, put 4 oz. extract of indigo; enter, and winch in this 15 minutes; lift, give 1 water, and dry.

Lavender Vat.—50 lb. Boil 14 lb. logwood in 10 or 12 gallons water; decant the clear into a 60-gallon tub containing 40 gallons of water; when it is quite cold, add 45 lb. lavender spirits; rake up occasionally for 3 or 4 hours; next day it will be fit for working, and the glass will stand at 6° Tw. This will dye lilac; add neutralised paste for lavender. Renovate with raw muriatic acid till the glass stands at 6° Tw.

Lilac. — 100 yards. Scald 1½ lb. logwood, 2 lb. sumach. Decant, and work like the last; sadden, and top with logwood; raise with muriate of tin.

PINK.—For 30 lb. yarn, or 250 yards cloth. Bleed 7 lb. safflowers in 50 gallons soft water; dissolve 2 lb. tartar in 3 gallons hot water; enter the yarn in the safflower, and give 4 turns; lift, and put in one-half of the tartar; enter; 4 turns more; lift again, and put in all the tartar, and work in it till you get the required shade.

RED, BARWOOD.—For 40 lb. 10 lb. sumach; spirit vat, 2½° Tw.; 40 lb. barwood; 1 quart red spirits; done in the same manner as limawood red.

RED, CLARET.—For 50 lb. Preparation, 12½ lb. sumach; spirit tub, 3° Tw. Dyeing, 15½ lb. limawood; 2 lb. logwood, to blue. Raising, 1 quart red spirits for cotton. 8 to 10 hours in the sumach; work 1 or 2 hours in the spirit tub; wash out of it in 3 waters; boil the limawood and logwood; decant into a large tub; winch 30 minutes; lift, and give the raising; enter again for 15 minutes; lift, wash, and dry.

RED, CRIMSON WITH COCHINEAL.—For 50 lb. Prepare with 15 lb. sumach and 10 lb. alum. Dye with 6¼ lb. cochineal. Twenty-four hours in the sumach; lift; make up a hot solution of alum; winch in that 2 or 3 hours; lift; wash in 2 waters; then boil the cochineal; put off the boil; enter, and winch till full enough; then wash and dry.

RED, CRIMSON VAT.—Boil 1 cwt. limawood; decant it in the same manner as the last, and add 56 lb. crimson vat spirits; renovate with killed spirits, 7° Tw.

RED, LIMAWOOD.—For 40 lb. 10 lb. sumach; spirit vat, 2½° Tw.; 12 lb. limawood; 1 quart red spirits. After being prepared with sumach, winch it in the spirit vat for 2 hours; lift, and wash well in 3 waters; boil or scald the limawood; decant the clear liquor into another vessel; enter, and winch in this for 30 minutes; lift, and raise in the same liquor, with 1 quart of red spirits.

RED, PURPLE.—For 50 lb. Preparation, 12½ lb. sumach; spirit tub, 2½° Tw. Dyeing, 15 lb. logwood. Raising, 1 quart purple spirits; wrought like claret.

RED, PURPLE VAT.—Boil 1 cwt. of the best logwood in 30 gallons of water for 3 or 4 hours, when it will be reduced to 26 gallons; decant the clear liquor into a wood or stone vessel; let it stand till quite cold, and add 56 lb. purple vat spirits, 7° Tw. In renovating this vat, it is made up with raw muriatic acid till the glass stands as high as when set.

RED, ROSE PINK VAT.—Boil 1½ lb. of limawood in 3 gallons water; decant the clear into a tub containing 20 gallons water, and add 5 quarts double muriate of tin; the hydrometer will stand at 7° Tw.; renovate with double muriate of tin.

RED, RUBY.—For 50 lb. Preparation, 12½ lb. sumach; spirit tub, 3° Tw. Dyeing, 12½ lb. limawood; 1 lb. logwood to blue. Raising, 1 quart red spirits; wrought like claret.

RED, SCARLET.—For 40 lb. Preparation, 16 lb. sumach; spirit tub, 3° Tw. Dyeing, 24 lb. limawood, 3½ lb. turmeric. Raising, 6 lb. alum. After lying in sumach 24 hours, lift, and winch it in the spirit tub; wash well out; boil the wood; decant the clear liquor into a large tub; enter, and winch for 30 minutes; then raise with alum.

STONE.—For 50 lb. Boil 4 lb. fustic, 2 lb. limawood, 2 lb. madder. Decant and work in this 15 minutes; air out and repeat; lift, and add 4 or 6 oz. copperas; enter again, and work till you get the required shade; then wash and dry.

YELLOW, BUFF.—Give nitrate of iron 6° Tw., 150° F.; winch in this till full enough, then lift; give 2 waters; raise in a solution of lime, 1° Tw.; if not dark enough, repeat in the iron tub, then in the lime.

YELLOW, CHROME.—For 50 lb. 10 lb. acetate of lead, 5 lb. chrome. Dissolve separately and put each into a tub containing 100 gallons water; enter in the lead first, 4 or 5 turns; wring out; then through chrome; continue from the one to the other till dark enough.

YELLOW, OLIVE.—For 50 lb. 10 lb. bark, 2 lb. logwood, 8 oz. bluestone. Boil the bark in a bag; put off the boil, and enter; winch 20 minutes; lift, and put in the bluestone; return for 10 minutes; lift and wash in 2 waters, and top; give the logwood in another dish; when dark enough, wash and dry.

YELLOW, ORANGE.—(*a*) For 40 lb. 2½ lb. annatto, 24 lb. bark, 3 quarts muriate of tin. Boil the annatto; put off the boil; enter, and winch till it has a good body; wring out, wash well, wring again, and shake out; then, in a clean boiler, boil the bark in a bag for 15 minutes; add the muriate of tin, and enter; winch at the spring till the required shade is got.

(*b*) For 50 lb. Bottoming, 1½ lb. annatto. Dyeing, 5 lb. bark, 3 quarts muriate of tin. Give the annatto boiling hot; wash in 2 waters; boil the bark, and add the muriate of tin; enter; winch 20 minutes, then wash and dry.

COTTON SPIRITS, RED.—(*a*) For 50 lb. 40 lb. muriatic acid, 10 lb. nitric acid, carefully and slowly killed with 9½ lb. of tin, or 3 oz. of tin to the pound.

(*b*) PURPLE.—2 quarts muriatic acid, feed with 1½ lb. tin, or 1½ oz. to the gill.

Silk.—For dyeing purposes we may consider that 1 lb. of silk woven into common sarsenet, measures about 13 yards: this multiplied by 16, gives 208; or for a more convenient standard, we may calculate 200 yards at 16 lb., 100 at 8 lb., and so on.

When satins, satinets, sarsenets, or silks of any kind are found to contain shots, that is, warp and weft of different qualities, they must be prepared as follows:—For 100 yards. Dissolve 1½lb. salt of tartar in a copper containing 150 gallons boiling water; winch in this one hour; lift, and wash in 2 waters; and then prepare for any colour. If, after dyeing black, brown, or any colour, the silk is found to contain a shot of different silk, it must be discharged to the bottom, and put through the stuff as directed; then prepare a new, for whatever colour required.

BLACK.—(*a*) For 200 yards or 16 lb. Prepare in a hot solution of nitrosulphate of iron, 5° Tw., 150° F.; work 30 minutes in this; lift, and wash well in 3 warm waters; then boil 18 lb. of fustic; put off the boil; enter, and winch for 30 minutes; lift; boil 16 lb. logwood, put off the boil, and decant the clear liquor into a large tub; add 1 lb. of white soap; enter, and winch for 30 or 40 minutes in this; lift; wash in 2 waters, and you will have a brilliant jet black.

(*b*) For 200 yards. After being cleaned, prepare in a cold solution of nitrate of iron, 5° Tw. (this is strong enough for light silks, 4° or 4½ Tw. will do for dark and dipping silks); 30 minutes in this; lift; boil 14 lb. fustic; put off the boil; enter, and winch 30 minutes; lift; wash in 3 waters, blood-warm; then boil 16 lb. logwood; decant as before; give the same quantity of soap, and finish in the same way.

(*c*) For 200 yards. After being cleaned or scalded, discharge in a hot vitriol sour; a cold and then a warm water out of the sour; run through another scald, and 2 warm waters; then boil 14 lb. fustic; put off the boil; winch 30 minutes, and lift for saddening; make up a solution with some of the fustic left in the last process, and 1 lb. copperas; winch in this for half an hour; wash in 3 waters; dye with 16 lb. logwood and 1 lb. of soap.

(*d*) Work 5 lb. silk in a mixture of 2 lb. fustic chips; 1 lb. quercitron bark; lift; then add 6 oz. verdigris, 6 oz. copperas; work for quarter of an hour, and hang up all night; wash and dye with a decoction of 5 lb. logwood with as much white as will make a lather.

BLUE, PALE.—For 100 yards. 3 oz. paste or extract of indigo; 6 oz. tartaric acid. Sour first in a hot solution of sulphuric acid (about 1½ gill), lift, and wash in 1 water. Prepare the paste and dissolve the acid in a little hot water; then take a copper or stoneware vessel of sufficient size, fill it nearly full of water, 110° F.; put it in the paste, and 5 parts of the tartaric acid; winch in this 15 minutes; lift; wash in cold water; harden with the part of tartaric not used; lift, and dry.

In dyeing printed silks, containing black or any colour you wish to retain, they must not be soured in dyeing, and use as little raising as possible.

To prepare extract of indigo.—Every particle must be well broken with a palette knife, or the back of a tablespoon, after which pour on a little boiling water; stir it up and let it settle for a little before using.

Blue, Royal.—Prepare in a solution of nitrate of iron, 3° Tw., 100° F.; and for every pound of prussiate used in dyeing, add as much of the crystals of tin (dissolved in hot water) to the preparation; work in this till the silk turns a light buff colour; lift, and wash in 1 water; after which, for 100 yards, dissolve 4 lb. prussiate of potash in a little boiling water; put this into a copper containing 80 gallons water, 120° F.; add 1½ gill sulphuric or muriatic acid; enter in this; winch 15 minutes; lift; 1 water; run again through the preparation; add 2 gills sulphuric acid to the prussiate; repeat in it, and if not dark enough, lift, and add a little nitrate of iron; after getting it to the required shade, give 2 waters; then harden in a solution of alum; and dry in a hot stove.

Brown, Cinnamon.—For 100 yards. Boil 12 lb. fustic, 3 lb. ground madder, 2 lb. barwood. Cool to 200° F., then enter, and winch 20 minutes; air out, and repeat; with a little of the liquor in another dish, sadden to pattern with 4 or 5 oz. copperas, 1 or 2 shots; wash in 2 waters, and dry.

Brown, French.—Prepare in a hot solution of alum, for 10 or 12 hours; lift, and wash in 2 waters; boil or scald. For 10 yards. Limawood, 1 lb.; ground fustic, 4¾ oz. Decant the clear of both liquors into another dish; enter, and winch for 30 minutes; air out, and repeat; if dark enough, wash in 2 waters, and dry. Common brown is done in this way by adding a little logwood.

In preparing this colour, a little copperas is sometimes used along with the alum; when done in this manner, raise slightly with muriate of tin.

Brown, Olive.—For 10 yards. Boil fustic, 1 lb.; logwood, 3¼ oz.; cudbear, 2½ oz. Cool to 200° F.; enter, and winch for 20 minutes; air out; repeat; sadden to pattern with 4 oz. copperas; wash and dry.

Drab.—For 100 yards. Boil 4 lb. fustic and 6 oz. logwood; 2½ oz. cudbear; 1¾ oz. copperas. Cool to 200° F.; enter; winch 20 minutes; air out; repeat; then take a little of the liquor out of the boiler, dissolve the copperas, reduce it to handling heat with water, and give 1 or 2 shots through it as the pattern requires; 1 water out of the saddening; then give a warm, but weak sour, to clear the colour; wash in 2 waters, and dry.

Before using cudbear, it must always be drenched with a little hot water, to the consistency of paste; then scald or boil it as occasion may require.

Fawn.—For 10 yards. Fustic, 6½ oz.; cudbear, ½ oz.; copperas, 1½ drachm. Use as for Drab.

Green, Common Pale.—For 11 yards. Extract of indigo, 2 oz.; ebony, 1¾ oz.; alum, 1¾ oz.; sulphuric acid, 1¼ oz. Work as for Pea Green.

Green, Grass.—For 10 yards. Fustic, 12 oz.; extract of indigo, 3 oz. 3 dr.; alum, 3 oz. 3 dr.; sulphuric acid, 1½ oz. Boil the fustic first; then add the extract of indigo, alum, and acid; put off the boil; enter and winch till you get the shade required; if not blue enough, give more extract of indigo; if not yellow enough, more fustic.

Green, Myrtle.—For 10 yards. Fustic, 1 lb.; logwood, 3 oz. 3 dr.; extract of indigo, 3 oz. 3 dr.; bluestone, ½ oz. Boil the logwood and fustic together; put off the boil; enter; winch 20 minutes; air out and repeat; raise with 3 oz. bluestone dissolved in the boiler; then give the extract of indigo; 1 water; rinse in the remaining 2 oz. bluestone; harden in a solution of alum, and dry.

Green, Olive.—For 100 yards. 10 lb.

fustic, 2 lb. logwood, 10 oz. camwood. Boil altogether for 30 minutes, put off the boil; enter and winch for 20 minutes; air out and repeat: sadden with 3 or 4 oz. copperas in the same liquor, or with a little of the liquor in another dish; when the required shade is got, wash and dry.

Green, Pea.—For 100 yards. 10 oz. extract of indigo, 2½ lb. ebony, 1 lb. alum. Sour first; wash in 1 water; boil or scald the ebony; decant the clear into another dish, and add the extract of indigo and alum; enter in this, and winch for 10 or 15 minutes; wash in 1 water.

Lavender.—Same as lilac, by adding a little neutralised extract of indigo. Break 4 oz. of extract of indigo; dilute it with 2 quarts of hot water, and add half an ounce of soda, to destroy or neutralise whatever acid the extract contains; after stirring it well up, let it stand for two days, then strain it for use. Silver grey gets less stuff than lavender.

Lilac.—The best lilac is dyed upon nitro-sulphate of iron spirits; when without these, the following is the simplest method:—10 gallons water, 1 pint purple vat. Add raw muriatic acid till the glass stands at 6° Tw.; enter in this, and work till you get the required shade; if too light, add more purple liquor, wash in 2 warm waters, and dry.

Red: Claret.—Prepare with alum like the last; boil or scald. For 10 yards. Limawood, 1¼ lb.; logwood, 3¾ oz. Decant the clear of both liquors into a tub of sufficient size; enter and winch for 30 minutes; air out, and repeat; when dark enough, wash and dry.

Red: Crimson.—For 10 yards. Bottoming, cudbear, 1½ oz.; preparation, tartar, 1¼ oz.; scarlet spirits, 3½ oz.; dyeing, cochineal, 2 oz. Boil or scald the cudbear; winch in this 30 minutes; then prepare and dye as before.

Red: Pink.—For 10 yards. Bottoming, blue archil, ½ oz.; dyeing, safflower, 2 oz.; raising, tartaric acid, ½ oz. Put the archil into 100 gallons boiling water; winch in this 15 minutes; lift; bleed; then refine the safflower with cotton; make up a safflower liquor of 100 gallons; enter and winch 15 minutes; lift; put in half the raising; return and winch 10 minutes; lift again and add the other half of the raising; return for 10 minutes more; then wash in 1 water; harden with a little tartaric in another, and dry.

Rose colour may be made in this way, by giving more stuff.

To Prepare Safflower.—Steep 2½ lb. safflower all night in water; in the morning rub the cakes between the hands, so that it may be all broken; then put it into a bag or close sieve; stand with it under a good run of water until the particles are all disengaged from each other, and purged of impurities; then put 20 or 30 gallons of water into a large tub, add ½ lb. soda dissolved, and put in the safflower; stir it up, and let it bleed 30 or 40 minutes; then strain it through the bag into a second tub; if not well enough bled, repeat in the first tub with a little more soda. To refine safflower after being bled,—immerse 3 or 4 lb. cotton yarn or cloth in it; in 10 minutes lift, and add a little tartaric; return for 10 minutes; add a little tartaric again; return for 10 minutes more; lift, and add the tartaric a third time, at which time it must do no more than taste slightly sour; then wash in 2 or 3 waters, after which it must be bled in a tub of clean water with a little soda; then make up this liquor with water for dyeing.

Red: Purple.—The best purples are made upon the purple vat. For a red shade, wash in 2 cold waters; for a blue shade, wash in 2 hot waters. Another but inferior method is, to prepare with alum, dye with logwood, and raise with double muriate of tin.

Red: Royal Blue Purple.—For whatever depth of colour required, winch upon the purple vat, wash in 2 warm waters; then put a little extract of indigo into a tub of cold water; add a little sulphuric acid; enter and work in this till you get the required shade, then wash in cold water, and dry.

Red: Rose Colour with Cochineal.—For 10 yards. Bottoming, blue archil, ¾ oz.; preparation, tartar, ¾ oz.; scarlet spirits, 2½ oz.; dyeing, cochineal, fully 1½ oz. Bottom with archil; lift; dissolve the tartar, and put it and the spirits into 100 gallons water; winch in this for some time; then let it lie 12 hours (if this preparation is made hot, 3 or 4 hours will do); pound, and then boil the cochineal; put off the boil; lift out of the preparation, and enter; winch till the liquor cools, and the colour will be full enough.

Salmon Colour.—For 10 yards. Annatto, 1¼ oz.; cudbear, 4 dr. Boil the annatto; then add the cudbear; put off the boil; enter and winch 30 minutes; wash in 2 waters; then dry.

Scarlet.—For 10 yards. Bottoming, annatto, fully 1½ oz.; preparation, tartar, 1¼ oz.; scarlet spirits, 3½ oz.; dyeing, cochineal, 2½ oz. Bottom with the annatto, 212° F.; winch 15 or 20 minutes, and it should be a full orange; then give the preparation and cochineal as for rose colour.

Slate.—For 100 yards. 8 oz. cudbear, 2 lb. logwood, 1 lb. tartar. Bottom with the cudbear; lift; boil the logwood; decant into a tub of sufficient size; enter and winch in this for 15 minutes; lift and raise with the tartar at twice, then wash and dry.

Stone.—For 100 yards. 3 lb. fustic, 7½ oz. logwood, 2½ oz. cudbear, 2 oz. copperas. Use as for Drab.

Yellow: Amber.—For 10 yards. Annatto, 1½ oz.; bark, 1¼ oz.; muriate of tin, 2½ oz. Bottom with the annatto, and top with the bark and muriate of tin. Use as for Orange.

Yellow: Buff.—For 10 yards. Annatto, 1½ oz.; vitriol, 1½ oz. Give the annatto at 212° F.; when full enough, lift; wash in 2 waters; then raise with the vitriol.

Yellow: Chamois.—For 10 yards. Annatto, 9½ dr.; fustic, 6½ oz.; madder, 6½ dr.; cudbear, 3¼ dr. Bottom with the annatto, 212° F.; wash in 1 water; boil the fustic, madder, and cudbear together; put off the boil, and enter; winch 15 minutes; if not full enough, air out and repeat; then wash and dry.

Yellow: Cream Colour.—For 10 yards. Boil annatto, 9½ dr.; vitriol, 1 oz. Work in the same manner as Buff.

Yellow: Orange.—For 10 yards. Annatto, 1¾ oz.; bark, 1¼ oz.; muriate of tin, 1½ oz. Give a good body of annatto, 212° F.; wash in 1 water; then top with the bark and muriate of tin.

Yellow: Straw.—For 10 yards. Annatto, 6½ dr.; barks, 1¼ oz.; muriate of tin, 1½ oz. Give the annatto on the bottom 212° F.; 1 water out, and then give the barks and muriate of tin, same heat.

Before using annatto, it must be boiled with half its weight of American ashes, in the least possible quantity of soft water. This applies to every process where annatto is used.

Ammonia Paste.—1 quart strong ammonia, 1 ditto water, 2 lb. ground cochineal. Stir them all well together in a stone pot; tie up the mouth of it tightly, and set it in some warm place, such as the flue of a stove, for two days, and it will be fit for use.

Indigo, Extract of.—1 lb. best ground indigo, 6 lb. double vitriol. Mix together; let stand 48 hours in a stone pot; then put the vessel into a warm bath till properly dissolved; take 6 gallons water, 170° F.; add the indigo slowly, filter through woollen cloth, covered with brown paper, into a wooden vessel; what remains on the paper put away, as it is only earth; then add your liquor, 4 lb. common salt, 1 lb. pearl-ash. Let it stand till it ceases fermenting, then filter again through brown paper, and what remains on the paper is pure extract of indigo; there should be 12 lb. of it.

Silk Spirits. (*a*) Nitro-sulphate of Iron.—2 gal. of 30 lb. double aquafortis, 24 lb. copperas. Put the aquafortis into a leaden or stoneware pot; place it near a fire, and add the copperas at 3 or 4 times; if without the convenience of a fire, put in a quart of hot water with the first of the copperas.

(*b*) Nitrate of Iron.—2 gal. aquafortis, 5½ lb. old iron. Put this into a 6-gallon pot; add the iron by degrees; and keep it warm, like the last.

(*c*) Scarlet.—3 lb. muriatic acid, 3 lb. pure double nitric acid; add 2 oz. sal ammoniac, and feed with 1½ lb. granulated tin.

(*d*) Purple Vat Spirits.—4 gal. (54 lb.) muriatic acid, 1¼ gal. (20 lb.) nitric acid. Kill with 3½ lb. granulated tin; ¾ oz. to the pound.

(*e*) Crimson Vat Spirit.—3 gal. muriatic acid, 2 gal. nitric acid, 2 oz. sal ammoniac, fed with 3½ lb. tin.

(*f*) Lavender.—30 lb. muriatic acid, 15 lb. double nitric acid. Kill with 3 lb. granulated tin; nearly 1 oz. to the pound.

MURIATE OF TIN. — (*a*) Give any quantity of muriatic acid as much tin as it can consume; you will know when it has enough, by seeing tin lying undissolved at the bottom of the pot.

(*b*) *Double.*—It requires twice as much tin as the last; it may be made by heating common muriate of tin in a stoneware pot, placed in a hot sand-bath, and giving as much tin as it can consume.

Woollen.—1 lb. of wool woven into common merino measures about 3 yards, common moreen about 2 yards.

BLACK.—(*a*) For 50 lb. Prepare with 2¼ lb. chrome; boil half an hour, and wash in 2 waters. Dye with 20 lb. logwood and 2 lb. fustic. Boil ½ hour; 1 water, then a slight sour, moderately warm; 1 cold water, and finish out of a warm one, softened with a little urine.

(*b*) For 50 lb. Prepare with 2 lb. chrome, 1 lb. tartar, and 1 quart muriate of tin; boil 1 hour, and wash in 2 waters. Dye with 25 lb. logwood and 3 lb. fustic. Boil 30 minutes, lift, add 1 pint vitriol. Return for 10 minutes, then wash and dry. To render this blue-black, omit the fustic.

(*c*) 3 lb. green copperas, 3 lb. tartar, ½ lb. sulphate of copper, 1 lb. fustic, 1 lb. logwood. Boil for ½ hour; enter, and boil the cloth 3 hours; wash; then enter into a vat with 11 lb. logwood; boil 1 hour; raise; enter into logwood vat for ½ hour, and finish.

BLUE, PALE.—For 50 lb. 1 gill sulphuric acid, 3 oz. extract of indigo, 1 lb. alum. Enter cold with one half of the extract; give the other half when the boiler warms; bring to the spring.

BLUE, ROYAL.—For 50 lb. 3½ lb. super-sulphate of tartar, 3½ lb. prussiate of potash, 2 lb. 10 oz. logwood, 3½ quarts royal blue spirits, 3½ pints muriate of tin. Into a boiler containing 100 gallons of water, put the prussiate and super-sulphate of tartar, after being dissolved in a little boiling water; have the logwood boiled beforehand, put it in, and one-half of the blue spirits; enter cool, heat up to 180° F., and lift; give the rest of the blue spirits; return and boil for ¼ hour; lift again, cool well and give the muriate of tin; return and boil 15 minutes; lift, wash, and dry.

BROWN, CINNAMON.—For 50 lb. 8 lb. fustic, 2 lb. madder, 10 oz. cudbear, 1 lb. tartar, 2 lb. alum. Give 2 runs, and sadden with 3 or 4 oz. of copperas.

BROWN, COMMON DARK.—For 40 lb. 6 lb. logwood, 12 lb. redwood, 4 lb. madder. Boil ½ hour, air out and repeat, then sadden with 1 lb. copperas; if too dark, raise to pattern with muriate of tin.

BROWN, FRENCH.—For 50 lb. Preparation, 1½ lb. chrome. Dyeing: 6 lb. fustic, 1 lb. ground madder, ½ lb. cudbear, 1 lb. tartar; and if not dark enough, add 8 oz. logwood. Boil ½ hour.

BROWN, OLIVE.—For 50 lb. Preparation, 1½ lb. chrome. Dyeing: 7 lb. fustic, 3 lb. madder, 1 lb. logwood, 2 lb. tartar, 8 oz. cudbear. 1 run; raise in the second with 5 or 6 oz. bluestone; wash well and dry.

DRAB.—(*a*) For 50 lb. 7 lb. fustic, 8 oz. madder, 4 oz. cudbear, 2 lb. alum, 8 oz. tartar. Enter between the cold and 160° F.; after heating up, boil from 10 to 30 minutes; wash in 2 waters. All dark shades of this and the four following colours may be slightly prepared with chrome; wash in 2 waters.

Light.—(*b*) For 50 lb. 4 lb. fustic, 1¾ lb. alum, 4 oz. madder, 4 oz. tartar, 3½ oz. cudbear. Work as for drab.

FAWN.—For 50 lb. 5 lb. fustic, 1 lb. madder, ½ lb. camwood, ½ lb. cudbear, 2 lb. alum. Work as for drab.

Green, Common Pale.—For 50 lb. 3½ lb. extract of indigo, 2½ lb. fustic, 10 oz. tartar, 1 gill sulphuric acid. Give the extract and acid first; when at 180° F., put in the fustic and tartar; boil 15 minutes.

Green, Grass.—For 50 lb. Boil 20 lb. fustic, 7 lb. extract of indigo, 1½ lb. tartar, 3 gills sulphuric acid.

Green, Olive.—For 50 lb. Prepare with 1½ lb. chrome; boil ½ hour, and wash in 2 waters; then boil 12 lb. fustic and 2½ lb. logwood for 1 hour; add 2 lb. madder and 2 lb. redwood. Enter; boil ½ hour. Raise in the same liquor with 4 oz. bluestone; wash well and dry.

Green, Pea.—For 54 lb. 2 lb. extract of indigo, 7 lb. fustic, 1 lb. alum. Bring on from the cold; when the boiler heats to 180° F., put in the fustic; boil 15 minutes.

Grey, French.—For 50 lb. Boil 7 lb. fustic and 12 oz. cudbear. Add 6 oz. extract of indigo, 1 pint sulphuric acid. Cool to 180° F.; enter, and boil 20 minutes.

Grey, Silver.—For 50 lb. Boil 1 lb. logwood and 2½ lb. alum. Add 5 oz. extract of indigo. Brought on from 100° F.; boil 10 minutes.

Lavender.—For 45 lb. Boil 2 lb. logwood and 2 lb. alum. Add 10 oz. extract of indigo. Enter cold and bring up to the boil.

Lilac.—For 50 lb. Boil 5½ lb. logwood and 2 lb. alum. Add 2 quarts muriate of tin, 8 oz. extract of indigo. Brought on from 100° F.

Peach.—For 50 lb. Drench 8½ lb. cudbear with a little hot water; boil or scald it in 3 or 4 gallons; decant the clear liquor into a boiler containing 100 gallons water; enter cold; bring to the boil; lift and put in 1 lb. soda, or 2 gallons urine; return and boil 10 minutes.

Red: Claret.—For 50 lb. Preparation; 1½ lb. chrome. Dyeing, 9 lb. limawood, 2 lb. logwood, ½ lb. tartar. Boil ½ hour.

Red: Cochineal Crimson. — For 50 lb. 3½ lb. cochineal, 2½ lb. tartar, 2 quarts crimson spirits. Boil ½ hour; wash well; blue with urine or a little ammonia, in a clean tub of warm water, 150° F.

Red: Fast Crimson. — For 50 lb. 6¼ lb. cochineal, ½ lb. cudbear. Boil in this ¾ hour; raise with 2 quarts crimson spirits; boil ¼ hour; lift, wash well, and dry.

Red: Limawood Crimson.—For 50 lb. Prepare with 2 lb. alum and ½ lb. tartar. Boil ½ hour; wash in 3 warm waters. Boil in 11 lb. limawood, and add ½ lb. cudbear. Boil in this for ½ hour, and blue with warm water.

Red: French Pink.—For 50 lb. 3 gills ammonia paste; 1¼ lb. tartaric acid, to redden; 10 oz. oxalic acid, to blue. Enter at 140° F.; heat no higher than 200° F.

Red: Purple.—For 50 lb. Preparation; 1½ lb. tartar and 1 lb. alum; wash in 3 waters. Dye with 10 lb. logwood; boil ½ hour; raise with 1 quart muriate of tin.

Red: Royal Purple.— For 50 lb. Blue on the woad vat, either warm or cold, for whatever depth of colour required; wash in 2 waters; then give 2½ lb. cudbear; boil ½ hour, or until you get the shade wanted; if not blue enough, give another run upon the vat.

Red: Royal Blue Purple.—For 50 lb. 10½ lb. logwood, 1¼ lb. prussiate of potash, 3½ lb. super-sulphate of tartar, 3½ quarts royal blue spirits, 3½ pints muriate of tin. Give the logwood at twice lest the colour get unlevel.

Red: Rose Colour.—For 40 lb. 1 lb. cochineal, 3 gills double muriate of tin, 1 lb. tartaric acid. Enter at 100° F.; heat up; boil 15 minutes; lift, and cool to 120° F., by throwing out part of the liquor, and filling up with water,—add 1 gill ammonia paste, 12 oz. tartaric acid, 6 oz. oxalic acid. Bring up to the boil; when the desired shade is got, wash well, and dry.

Red: Ruby.—For 50 lb. Preparation; 3 lb. tartar and 2 lb. alum. Boil ½ hour, and wash in 3 warm waters. Dyeing: S lb. limawood, ½ lb. cudbear. and ¾ lb. tartar. Boil ½ hour, and blue to pattern with hot water.

RED: SCARLET WITH COCHINEAL.—For 50 lb. Boil 4 lb. cochineal and 1¾ lb. bark. Add 3 lb. tartar, 2 quarts scarlet spirits. Enter at 200° F.; boil one hour; wash well. Sour before dyeing, either cold or warm; 1 water, out.

RED: SCARLET WITH LAC.—For 50 lb. Boil 5½ lb. lac and 1½ lb. bark. Add 3 lb. tartar, 2 quarts lac scarlet spirits. Enter at 200° F.; boil 1 hour; wash well. Sour as before.

RED: SCARLET WITH LAC AND COCHINEAL.—For 50 lb. Boil 4½ lb. lac and 1¾ lb. bark. Add 2 lb. tartar, 2 quarts lac scarlet spirits. Enter at 200° F.; boil in this 30 minutes; lift, and wash well: then, in a boiler of clean water, boil 14 oz. cochineal and 14 oz. tartar. Add 1½ pint scarlet spirits. Enter at 200° F.; boil 20 minutes, and wash well out. Sour before dyeing.

SLATE.—For 50 lb. 1 lb. logwood, 8 oz. extract of indigo, 4 oz. fustic, 2 lb. tartar, 2 lb. alum. Work as for drab.

STONE.—For 50 lb. 1 lb. logwood, 4 oz. fustic, 8 oz. extract of indigo, 3 lb. alum, 1½ lb. tartar. Work as for drab.

YELLOW.—For 40 lb. 2½ lb. bark, 2 lb. tartar, 2 quarts muriate of tin. Enter at 150° F.; boil 30 minutes.

YELLOW: AMBER.—For 40 lb. Boil 4 lb. bark and 8 oz. madder. Add 2 quarts muriate of tin, 1 lb. tartar. Enter at 200° F.; boil 30 minutes.

YELLOW: BUFF.—For 45 lb. Boil 4½ lb. fustic and 1½ lb. madder. Add 7 lb. alum. Enter at 200° F.; boil 30 minutes.

YELLOW: ORANGE.—For 50 lb. Boil 10 lb. bark and 1½ lb. cochineal. Add 2 lb. tartar, 2½ quarts yellow spirits. Enter at 200° F.; boil 30 minutes.

YELLOW: PRIMROSE.—For 50 lb. Boil 2½ lb. bark. Add 2 lb. tartar, 2 quarts muriate of tin. Enter at 150° F.; boil 30 minutes.

YELLOW: STRAW.—For 50 lb. Boil 3¼ lb. quercitron bark and 3 oz. cochineal. Add 2½ lb. tartar, 3 quarts muriate of tin. Enter at 150° F.; boil 30 minutes.

WOOLLEN SPIRITS.—Royal blue, 2 quarts of muriatic acid, 1 ditto nitric acid, no tin. Before using, let it stand until the gas goes off.

Scarlet Spirit.—Put any quantity of nitre, and the same of clear water, into a stoneware pot; the water first; then add 1 lb. muriatic acid to every 5 lb. of the above, and give 2 oz. of tin to the pound of spirits, adding it very slowly for one or two days, because in giving the tin too fast the spirits get fired, which precipitates the nitre, and they are lost.

Crimson Spirits are the same as scarlet spirits, but have more tin dissolved in them; give as much as they will take, till they turn of a bluish colour.

Lac Scarlet Spirit.—3 gal. muriatic acid, 2 gal. water, feed with 6 lb. tin, 1 gal. nitric acid.

Purple Spirts.—1 gal. muriatic acid, feed with 2 lb. granulated tin, or an ounce to every gill.

ASH VAT.—400 gal. water, heat to 170° F., 5 lb. ground indigo, 10 lb. American potash, 3 lb. madder, 4 lb. bran. Apply a slow fire, and it will come to fermentation in 14 or 16 hours; then add 1 or 2 lb. madder. In renovating this vat, use more potash in proportion to your indigo, than in setting a new vat.

ENGRAVING.

Copper.—Engraving on copper is performed by cutting lines representing the subject on a copper plate by means of a steel instrument, called a graver, or burin, ending in an unequal-sided pyramidal point. Besides the graver, the other instruments used in the process are a scraper, a burnisher, an oilstone, and a cushion for supporting the plate. In cutting the lines on the copper, the graver is pushed forward in the direction required, being held at a small inclination to the plane of the copper. The use of the burnisher is to soften down the lines that are cut too deeply, and for burnishing out scratches in the copper; it is about 3 inches long. The scraper, like the burnisher, is of steel, with three sharp edges to it; it is about 6 inches long, tapering towards the end. Its use is to scrape off the burr raised by the action of the graver. To show the appearance of the work during its progress, and to polish off the burr, engravers use a roll of woollen or felt, called a rubber, which is used with a little olive-oil. The cushion, which is a leather bag about 9 inches diameter filled with sand, for laying the plate upon, is now rarely used except by writing engravers. For architectural subjects, or for skies, where a series of parallel lines are wanted, a ruling machine is used, which is exceedingly accurate. This is made to act on an etching ground by a point or knife connected with the apparatus, and bit-in with aquafortis in the ordinary way.

COPPER PLATE.—The plate must be perfectly polished, very level, and free from any imperfection; to this must be transferred an exact copy of the outlines of the drawing. To do this the plate is uniformly heated in an oven or otherwise till it is sufficiently hot to melt white wax, a piece of which is then rubbed over it and allowed to spread, so as to form a thin coat over the whole surface, after which it is left in a horizontal position till the wax and plate are cold. A tracing having been taken of the original design with a black-lead pencil on a piece of thin tracing paper, it is spread over the face of the prepared plate, with the lead lines downwards, and, being secured from slipping, a strong pressure is applied, by which operation the lead lines are nearly removed from the paper, being transferred to the white wax on the plate. The pencil marks on the wax are now traced with a fine steel point, so as just to touch the copper; the wax is then melted off, and a perfect outline will be found on the copper, on which the engraver proceeds to execute his work.

Gold and Silver.—(*a*) The engraving is first exposed to the vapour of iodine, which deposits upon the black parts only. The iodised engraving is then applied, with slight pressure, to a plate of silver, or silvered copper, polished in the same manner as daguerreotype plates. The black parts of the engraving which have taken up the iodine part with it to the silver, which is converted into an iodide at those parts opposite to the black parts of the design. The plate is then put in communication with the negative pole of a small battery, and immersed in a saturated solution of sulphate of copper, connected with the positive pole by means of a rod of platinum. Copper will be deposited on the non-iodised parts, corresponding to the white parts of the engraving, of which a perfect representation will thus be obtained; the copper representing the white parts, and the iodised silver the black parts. The plate must be allowed to remain in the bath for only a very short time, for, if left too long, the whole plate would become covered with copper. The plate, after having received the deposit of copper, must be carefully washed, and afterwards immersed in a solution of hyposulphite of soda to dissolve the iodide of silver, which represents the black parts; it is then well washed in distilled water, and dried.

(*b*) Heat a silver plate, previously coated with copper, to a temperature sufficient to oxidise the surface on the copper, which successively assumes different tints, the heating being stopped when a dark-brown colour is obtained. It is then allowed to cool, and the exposed silver is amalgamated—the plate being slightly heated, to facilitate the operation. As the mercury will not combine with the oxide of copper, a design is produced, of which the amalgamated parts represent the black, and the parts of the plate covered with oxide of copper represent the white parts. The amalgamation being complete, the plate is to be covered with three or four thicknesses of gold leaf, and the mercury is evaporated by heat, the gold only adhering to the black parts. The superfluous gold must then be cleared off with the scratch-brush; after which the oxide of copper is dissolved by a solution of nitrate of silver; and the silver and copper under neath are attacked with dilute nitric acid. Those parts of the design which are protected by the gold, not being attacked, correspond to the black parts of the plate; the other parts, corresponding to the white parts of the engraving, may be sunk to any required depth. When this operation is completed, the plate is finished, and may be printed from in the ordinary method of printing from woodcuts.

(*c*) To obtain from the same prints plates with sunk lines, similar to the ordinary engraved copper-plates, a plate of copper, covered with gold, is operated upon. On immersion in the sulphate of copper solution, the parts corresponding to the white parts of the engraving will become covered with copper. The iodine, or compound of iodine, formed, is then removed by the hyposulphite; the layer of deposited copper is oxidised, and the gold is amalgamated, which may be removed by means of nitric acid, the oxide of copper being dissolved at the same time. In this instance the original surface of the plate corresponds to the white parts of the print, and the sunk or engraved portions to the black parts, as in ordinary copper-plate engravings.

Lithography.—The following are the principles on which the art of lithography depends;—the facility with which calcareous stones imbibe water; the great disposition they have to adhere to resinous and oily substances; and the affinity between each other of oily and resinous substances, and the power they possess of repelling water, or a body moistened with water. Hence when drawings are made on a polished surface of calcareous stone, with a resinous or oily medium, they are so adhesive that nothing short of mechanical means can effect their separation from it; and whilst the other parts of the stone take up the water poured upon them, the resinous or oily parts repel it. When, therefore, over a stone prepared in this manner, a coloured oily or resinous substance is passed, it will adhere to the drawings made as above, and not to those parts of the stone which have been watered. The ink and chalk used in lithography are of a saponaceous quality; the former is prepared in Germany from a compound of curd or common soap, pure white wax, a small quantity of tallow and shellac, and a portion of lampblack, all boiled together, and, when cool, dissolved in distilled water. The chalk for the crayons used in drawing on the stone is a composition consisting of the ingredients above mentioned. After the drawing on the stone has been executed, and is perfectly dry, a very weak solution of nitric acid is poured upon the stone, which not only takes up the alkali from the chalk or ink, as the case may be, leaving an insoluble substance behind it, but lowers, to a small extent, that part of the surface of the stone not drawn upon, thus preparing it to absorb water with greater freedom. Weak gum water is then applied to the stone, to close its pores and keep it moist. The stone is now washed with water, and the printing ink is applied with rollers, as in letterpress printing; after which it is passed, in the usual way, through the press, the processes of watering and inking being repeated for every impression. If the work is inclined to get smutty, a little vinegar or stale beer should be put into the water that is used to damp the stone.

There is a mode of transferring drawings made with the chemical ink on paper prepared with a composition of paste, isinglass, and gamboge, which, being damped, laid on the stone, and passed through the press, leaves the drawing on the stone, and the process above described for preparing the stone and taking the impressions is carried into effect.

LITHOGRAPHIC STONES.—Stones are prepared for chalk drawings by rubbing two together, with a little silver sand and water between them, taking care to sift the sand to prevent any large grains from getting in, by which the surface would be scratched. The upper stone is moved in small circles over the under one till the surface of each is sufficiently even, when they are washed, and common yellow sand is substituted for the silver sand, by which means is procured a finer grain. They are then again washed clean, and wiped dry. It will be found that the upper stone is always of a finer grain than the under one. To prepare stones for writing or ink drawings, they are rubbed with brown sand, washed, and rubbed with powdered pumice; the stones are again washed, and each polished separately with a fine piece of pumice or water Ayr-stone. Chalk can never be used on the stones prepared in this manner. The same process is followed in order to clean a stone that has already been used.

LITHOGRAPHIC INK.—Tallow, 2 oz.; virgin wax, 2 oz.; shellac, 2 oz.; common soap, 2 oz.; lampblack, ½ oz. The wax and tallow are first put in an iron saucepan with a cover, and heated till they ignite; whilst they are burning the soap must be thrown in, a small piece at a time, taking care that the first is melted before a second is put in. When all the soap is melted the ingredients are allowed to continue burning till they are reduced one third in volume. The shellac is now added, and as soon as it is melted the flame must be extinguished. It is often necessary in the course of the operation to extinguish the flame and take the saucepan from the fire, to prevent the contents from boiling over; but if any parts are not completely melted, they must be dissolved over the fire without being again ignited. The black is next added. When it is completely mixed the whole mass should be poured out on a marble slab, and a heavy weight laid upon it to render its texture fine. The utmost care and experience are required in making both the ink and chalk, and even those who have had the greatest practice often fail. Sometimes it is not sufficiently burned, and when mixed with water appears slimy; it must then be remelted and burned a little more. Sometimes it is too much burned, by which the greasy particles are more or less destroyed; in this case it must be remelted, and a little more soap and wax added. This ink is for writing or pen-drawing on the stone. The ink for transfers should have a little more wax in it.

LITHOGRAPHIC CHALK. — Common soap, 1½ oz.; tallow, 2 oz.; virgin wax, 2½ oz.; shellac, 1 oz.; lampblack, ¼ oz. Mix as for *lithographic ink.*

LITHOGRAPHIC TRANSFER PAPER.—Dissolve in water ½ oz. gum tragacanth. Strain and add 1 oz. glue and ½ oz. gamboge. Then take 4 oz. French chalk, ½ oz. old plaster of Paris, 1 oz. starch; powder, and sift through a fine sieve; grind up, with the gum, glue, and gamboge; then add sufficient water to give it the consistence of oil, and apply with a brush to thin sized paper.

TRANSFERRING. — The drawing or writing made on the prepared side of the transfer paper is wetted on the back, and placed, face downwards, on the stone, which must previously be very slightly warmed, say to about 125° F. Pass the stone through the press four or five times, then damp the paper, and carefully remove it.

DRAWING ON STONE.—The subject should first be traced on the stone in red, great care being taken not to touch the stone with the fingers. Or the drawing may be done by means of a black-lead pencil; but this is objectionable, as it is difficult to distinguish the line from that made by the chalk or ink. Then, having a rest to steady the hand, go over the drawing with the chalk, pressing it with sufficient firmness to make it adhere to the stone. For flat tints, considerable practice is necessary to secure an even appearance, which is only to be obtained by making a great many faint strokes over the required ground. Lights may either be left, or, if very fine, can be scraped through the chalk with a scraper. If any part is made too dark, the chalk must be picked off with a needle down to the required strength.

ETCHING-IN, FOR PRINTING ON STONE.—Dilute 1 part of aquafortis with 100 parts of water. Place the stone in a sloping position, then pour the solution over it, letting it run to and fro until it produces a slight effervescence. Then wash the stone with water, and afterwards pour weak gum water over it. The acid, by destroying the alkali on the lithographic chalk, causes the stone to refuse the printing ink except where touched by the chalk; the gum water fills up the pores of the stone, and thus prevents the lines of the drawing from spreading. When the stone is drawn on with ink, there must be a little more acid used with the water than when the drawing is made with chalk. The roller charged with printing ink is then passed over the stone, which must not be too wet, and the impression is taken as before described.

ENGRAVING ON STONE.—The stone must be highly polished; pour the solution of aquafortis and water over it, washing it off at once. When dry, cover with gum water and lampblack; let this dry, then etch with a needle, as on copper. It is necessary to cut the surface of the stone through the gum, the distinction of light and dark lines being obtained by the use of fine or broad-pointed needles. Rub all over with linseed oil, and wash the gum off with water. The lines on the stone will appear thicker than they will print.

Imitating Woodcuts on Stone.—Cover with ink those parts meant to be black; scratch out the lights with an etching needle; the lines which come against a white background are best laid on with a very fine brush and lithographic ink.

Inking Roller.—Fasten a smooth piece of leather round a wooden roller of the required length.

Removing the Transfer.—The existing transfer is ground away by rubbing it with another piece of stone, putting sand between, like grinding flour between the millstones, using finer sand as it gradually wears away; then it is ground with rotten-stone till of the requisite fineness for the next transfer.

Transferring from Copper to Stone.—In transferring from copper to stone use prepared paper, that is, ordinary unsized paper, coated with a paste of starch, gum-arabic, and alum. Take about 60 parts of starch, and mix with water to a thinnish consistency over a fire; have 20 parts of gum ready dissolved, and also 10 parts of alum dissolved; when the starch is well mixed, put in the gum and alum. While still hot, coat the paper with it in very even layers, dry, and smooth out. Take an impression from the copper with the transfer ink; lay the paper on the stone, damp the back thoroughly with a sponge and water, and pass through the litho-press. If all is right, the impression will be found transferred to the stone, but it will of course require preparing in the usual manner. The great advantage gained is, that very many more impressions may be printed from stone than from a copper plate, and very much quicker.

Steel.—Engraving on steel is the same as copper-plate engraving, except in certain modifications in the use of the acids; therefore, so far as the process is concerned, no particular description is necessary; but the means employed for decarbonising and recarbonising first the steel plate, so as to reduce it to a proper state for being acted upon by the graving tool, must be explained. In order to decarbonate the surfaces of cast-steel plates, by which they are rendered much softer and fitter for receiving either transferred or engraved designs, pure iron filings, divested of all foreign matters, are used. The stratum of decarbonated steel should not be too thick for transferring fine and delicate engravings; for instance, not more than three times the depth of the engraving; but for other purposes the surface of the steel may be decarbonated to any required thickness. To decarbonate it to a proper thickness for a fine engraving, it is exposed for 4 hours to a white heat, enclosed in a cast-iron box with a well-closed lid. The sides of the box must be at least $\frac{3}{4}$ inch in thickness, and at least a thickness of $\frac{1}{2}$ inch of pure iron filings should cover or surround the cast-steel surface to be decarbonated. The box is allowed to cool very slowly, by shutting off all access of air to the furnace, and covering it with a layer of 6 or 7 inches of fine cinders. Each side of the steel plate must be equally decarbonated, to prevent it from springing or warping in hardening. The safest way to heat the plates is to place them in a vertical position. The best steel is preferred to any other sort of steel for the purpose of making plates, and more especially when such plates are intended to be decarbonated. The steel is decarbonated to render it sufficiently soft for receiving any impression intended to be made thereon; it is, therefore, necessary that, after any piece of steel has been so decarbonated, it should, previously to being printed from, be again carbonated, or reconverted into steel capable of being hardened.

In order to effect this recarbonisation or reconversion into steel, the following process is employed; a suitable quantity of leather is converted into charcoal, by exposing it to a red heat in an iron retort until most of the evaporable matter is off the leather. The charcoal is reduced to a very fine powder; then take a box made of cast iron of sufficient dimensions to receive the plate which is to be reconverted into steel, so that the intermediate space between the sides of the box and the plate may be about an inch. Fill the box with the powdered charcoal, and, having covered it with a well-fitted lid, let it be placed in a furnace similar to those used for melting brass, when the heat must be gradually increased until the box is somewhat above a red heat; it must be allowed to remain in that state till all the evaporable matter is driven off from the charcoal; remove the lid from the box, and immerse the plate in the powdered charcoal, taking care to place it so that it may be surrounded on all sides by a stratum of the powder of nearly a uniform thickness. The lid being replaced, the box, with the plate, must remain in the degree of heat before described for 3 to 4 hours, according to the thickness of the plate so exposed; 3 hours are sufficient for a plate of ½ inch in thickness, and 5 hours when the steel it 1½ inch in thickness. After the plate has been exposed to the fire for a sufficient length of time, take it from the box and immediately plunge it into cold water.

The plates, when plunged into cold water, are least liable to be warped or bent when they are held in a vertical position, and made to enter the water in the direction of their length. If a piece of steel, heated to a proper degree for hardening, be plunged into water, and suffered to remain there until it becomes cold, it is very liable to crack or break, and in many cases it would be found too hard for the operations it was intended to perform. If the steel cracks it is spoiled. Therefore, to fit it for use, should it not be broken in hardening, it is the common practice to heat the steel again, in order to reduce or lower its temper. The degree of heat to which it is now exposed determines the future degree of hardness or temper, and this is indicated by a change of colour upon the surface of the steel. During this heating a succession of shades is produced, from a very pale straw colour to a very deep blue. On plunging the steel into cold water, and allowing it to remain there no longer than is sufficient to lower the temperature of the steel to the same degree as that to which a hard piece of steel must be raised to temper it in the common way, it not only produces the same degree of hardness in the steel, but, what is of much more importance, almost entirely does away with the risk of its cracking. The proper degree of temperature arrived at, after being plunged into cold water, can only be learned by actual observation, as the workman must be guided entirely by the kind of hissing noise which the heated steel produces in the water while cooling. From the moment of its first being plunged into the water the varying sound will be observed; and it is at a certain tone, before the noise ceases, that the effect to be produced is known. As a guide, take a piece of steel which has already been hardened by remaining in the water till cold, and by the common method of again heating it, let it be brought to the pale yellow or straw colour, which indicates the desired temper of the steel plate to be hardened. By the above process, as soon as the workman discovers this colour to be produced by dipping the steel into water and attending carefully to the hissing which it occasions, he will then be able, with fewer experiments, to judge of the precise time at which the steel should be taken out.

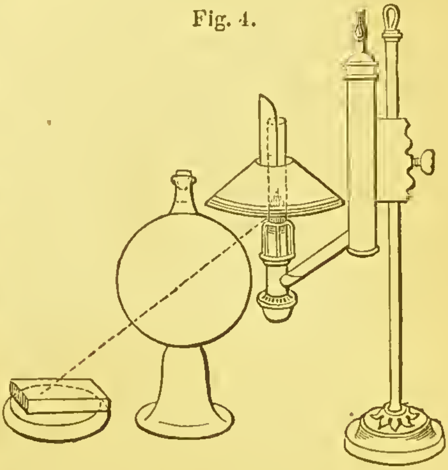
Immediately on withdrawing it from the water, the steel plate must be laid upon or held over a fire, and heated uniformly until its temperature is raised to that degree at which a smoke is perceived to arise from the surface of the steel plate after having been rubbed with tallow; the steel plate must then be again plunged into water, and kept there until the sound becomes somewhat weaker than before. It is taken out, and heated a second time to the same degree as before, and the third time plunged into water till the sound becomes again weaker than the last; exposed the third time to the fire as before; and for the last time returned into the water and cooled. After it is cooled, clean the surface of the steel plate by heating it over the fire. The temper must be finally reduced by bringing on a brown or such colour as may suit the purpose required.

The above is an old process and not generally used. Engraving on steel is effected nowadays by graving and etching like copper; using for biting-in a mixture of one part pyroligneous acid, 1 nitric acid, 3 water; run off from the plate in less than a minute, rinse in running water, and dry quickly. Use stronger acid when a deeper tint is required.

Engraving Steel Cylinders.—A cylinder of very soft or decarbonised steel is made to roll, under a great pressure, backward and forward on the hardened engraved plate till the entire impression from the engraving is seen on the cylinder in alto-relievo. The cylinder is then hardened, and made to roll again backward and forward on a copper or soft steel plate, whereby a perfect facsimile of the original is produced of equal sharpness.

Wood.—*Engravers' Lamp.*—A clear and steady light, directed immediately upon the block to be cut, is a most important point, and in working by lamplight it is necessary to protect the eyes from its heat and glare. The lamp shown in Fig. 4 can be raised or lowered at pleasure by sliding the bracket up or down the standard, it being fixed in the desired position by means of the small set screw. A large globe of transparent glass, filled with clean water, placed between the lamp and the block, causes the light to fall directly upon the block. The dotted line shows the direction of the light; by lowering the lamp, this light would take a more horizontal direction, thus enabling the engraver to work farther from the lamp. A shade over the eyes is occasionally used as a protection from the light of the lamp.

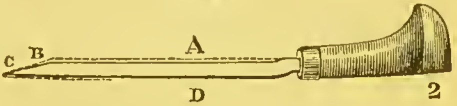
Fig. 4.



TOOLS.—These consist of gravers, tint-tools, gouges or scoopers, flat tools or chisels, and a sharp-edged scraper, something like a copper-plate engravers' burnisher which is used for lowering the block. Of each of these tools several sizes are required.

Gravers.—The outline tool Fig. 5, is chiefly used for separating one figure from another, and for outlines. A is the back of the tool; B, the face; C, the point; D is technically termed the belly. All the handles when received from the turner's are circular; but as soon as the tool has been inserted, a segment is cut away from the lower part so that the tool may clear the block. The blade should be very fine at the point, so that the line it cuts may not be visible when the block is printed, its chief duty being to form a termination to a number of

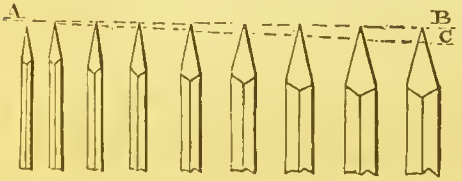
Fig. 5.



lines running in another direction. Although the point should be fine, the blade must not be too thin, for it would then only make a small opening, which would probably close up when the block was put in the press. When the tool becomes too thin at the point, the lower part must be rubbed on a hone to enable it to cut out the wood instead of sinking into it.

Nine gravers of different sizes, starting from the outline tool, are sufficient for ordinary work. The blades as made are very similar to those used in copper-plate engraving; the necessary shape for wood engraving is obtained by rubbing the points on a Turkey stone. The faces, and part of the backs, of nine gravers of different sizes, are shown on Fig. 6; the dotted line, A C, shows the extent to which the tool is sometimes ground down to broaden the point. This grinding rounds the point of the tool, instead of leaving it straight, as shown at A B. Except for the parallel lines, called *tints*, these gravers are used for nearly all kinds of work. The width of the line cut out is regulated by the thickness of the graver near the point, and the pressure of the engraver's hand.

Fig. 6.



Tint-tools.—The parallel lines forming an even and uniform tint, as in the representation of a clear sky, are obtained by what is called the tint-tool, which is thinner at the back, but deeper at the side, than the graver, and the angle of the face at the point is much more acute, as shown on Fig. 7: A is a side view of the blade; B shows the faces of nine tint-tools of varying fineness. The handle is of the same form as that used for the graver. The graver should not be used in place of the tint-tool, as from the greater width of its point a very slight inclination of the hand will cause a perceptible irregularity in the distance of the lines, besides tending to undercut the line left which must be carefully avoided. Fig. 8 shows the points and faces of the two tools, from a comparision of which this statement will be readily understood. As the width of the tint-tool at B is little more than at A, it causes only a very slight difference in the distance of the lines cut, if inclined to the right or the left, as compared with the use of the graver. Tint-tools that are strong in the back are to be preferred as less likely to bend, and giving greater freedom of execution than weak ones. A tint-tool that is thicker at the back than at the lower part, leaves the black raised lines solid at their base, as in Fig. 9, the block being less liable to damage than in the case of Fig. 10, in which the lines are no thicker at their base than at the surface. The face of both gravers and tint-tools should be kept rather long than short; though if the point be ground too fine it will be very liable to break. When, as in Fig. 11, the face is

Fig. 7.

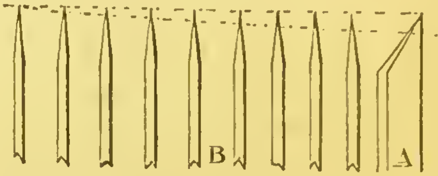


Fig. 8.

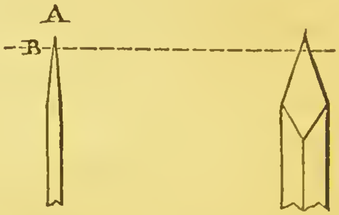


Fig. 9.

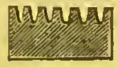


Fig. 10.

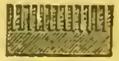
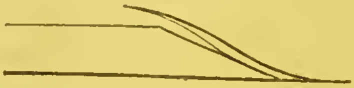


Fig. 11.



long,—or, strictly speaking, when the angle formed by the plane of the face and the lower line of the blade is comparatively acute,—a line is cut with much greater clearness than when the face is comparatively obtuse, and the small shaving cut out turns gently over towards the hand. When, however, the face of the tool approaches to the shape seen in Fig. 12, the reverse happens; the small shaving is rather ploughed out than cleanly cut out; and the force necessary to push the tool forward frequently causes small pieces to fly out at each side of the hollowed line, more especially if the wood is dry. The shaving, also, instead of turning aside over the face of the tool, turns over before the point, as in Fig. 12, and hinders the engraver from seeing that part of the pencilled line which is directly under it. A short-faced tool of itself prevents the engraver from distinctly seeing the point. When the face of a tool has become obtuse it ought to be ground to a a proper form; for instance, from the shape of the figure A to that of B, Fig. 13.

Fig. 12.

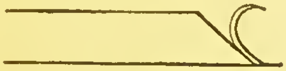
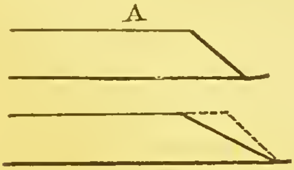


Fig. 13.



Preparing Gravers and Tint-tools.—Gravers and tint-tools, when first received from the makers, are generally too hard—a defect that is soon discovered by the point breaking off short as soon as it enters the wood. To remedy this, the blade of the tool must be tempered to a straw colour, and either dipped in sweet oil, or allowed to cool gradually. If removed from the oil while it is still of a straw colour it will have been softened no more than sufficient; but should it have acquired a purple tinge, it will have been softened too much, and instead of breaking at the point, as before, it will bend. A small grindstone is of great service in grinding down the faces of tools that have become obtuse. A Turkey stone is a very good substitute, as, besides reducing the face, the tool receives a point at the same time; but this requires more time. Some engravers use only a Turkey stone for sharpening their tools; a hone in addition is of great service. A graver that has received a final polish on a hone cuts a clearer line than one which has only been sharpened on a Turkey stone; it also cuts more pleasantly, gliding smoothly through the wood, if it be of good quality, without stirring a particle on either side of the line. The gravers and tint-tools used for engraving on a plane surface are straight at the point, as are here represented, Figs. 14 and 15; but for engraving on a block rendered concave in certain parts by lowering, it is necessary that the point should incline slightly upwards as in Fig. 14. The dotted line shows the direction of the point used for plane surface engraving. There is no difficulty in getting a tool to descend on one side of a part hollowed out or lowered; but unless the point is slightly inclined upwards, as is here shown, it is extremely difficult to make it ascend on the side opposite without getting too much hold, and thus producing a wider white line than intended.

Fig. 14.

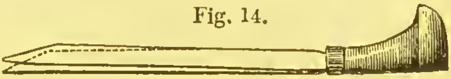
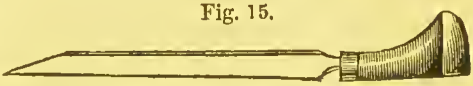
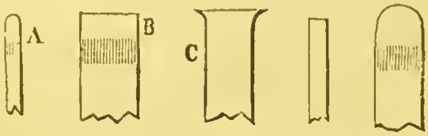


Fig. 15.



Gouges and Chisels, A to E, Fig. 16.—Gouges of different sizes are used for scooping out the wood towards the centre of the block; whilst flat tools, or chisels, are chiefly employed in cutting away the wood towards the edges, about $\frac{1}{8}$ inch below the subject. The gouge is similar to an ordinary carpenter's gouge, except that it is solid, being a round bar, with the end ground off at an angle. The other articles required are:—a sand-bag, on which to rest the block whilst engraving it; an agate burnisher and a dabber, which are used for taking proof-impressions of the wood-cut; an oil stone, and an eye-glass with shade.

Fig. 16.



Holding the Graver.—Engravers on copper and steel, who have much harder substances than wood to cut, hold the graver with the forefinger extended on the blade beyond the thumb, Fig. 17, so that by its pressure the point may be pressed into the plate. As boxwood, however, is much softer than these metals, and as it is seldom of perfectly equal hardness throughout, it is necessary to hold the graver in a different manner, and employ the thumb at once as a stay or rest for the blade, and as a check upon the force exerted by the palm of the hand, the motion being chiefly guided by the forefinger, as is shown in Fig. 18. The thumb, with the end resting against the side of the block, in the manner just represented, allows the blade to move backwards and forwards with a slight degree of pressure against it, and in case of a slip, it is ever ready to check the graver's progress. This mode of resting the thumb against the edge of the block is, however, only applicable when the cuts are so small as to allow the graver, when thus guided and controlled, to reach every part of the subject. When the cut is too large to admit of this, the thumb rests upon the surface of the block, as in Fig. 19, still forming a stay to the blade of the graver, and checking at once any accidental slip.

Fig. 17.

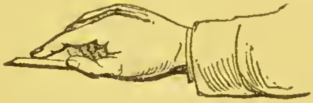


Fig. 18.

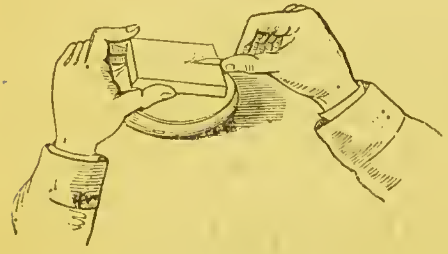
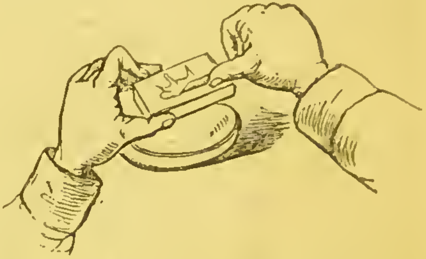


Fig. 19.



Wood.—For large coarse cuts, such as are often used for trade purposes, sycamore and pear tree may be employed, but they are too soft and irregular in the grain to bear fine work. Boxwood, either English, American, or from the Levant, is the favourite material; it should be of a light straw yellow colour, free from black or white spots, or red streaks, as these indicate a soft wood, which crumbles away under the graver. The small wood is generally tolerably free from blemishes. When a large cut is wanted, if a block of the required size is not at hand, several smaller blocks are sometimes bolted together. The blocks are cut a trifle thicker than the height of type, about an inch; they are then planed, brought to a very smooth surface, and gauged to the exact height of type. These blocks should be kept for some months until they are properly seasoned.

Drawing on the Block.—The polished boxwood will not take the pencil without a slight wash is first laid on it. A thin wash of Chinese white mixed with water, some very fine Bath brick dust, or the white scrapings of glazed cardboard, mixed with water, and gently rubbed off when dry with the palm of the hand, gives a capital surface for the black-lead pencil. Make a tracing of the outline of the subject, place a sheet of transfer paper on the block, lay the tracing over it, and go carefully over every line with a sharp point. It must be remembered that the woodcut will be reversed when printed. The outlines must be corrected, and completed, by a hard sharp-pointed H H H H pencil; the tints may afterwards be filled in by a softer pencil, or thin washes of Indian ink, to show the effect of light and shade. Caution must be taken to use these washes sparingly, so as not to affect the wood. All parts of the block, not being cut, must be kept covered up, so as to preserve the drawing from injury, and the fine lines of the cut from being blunted or broken. Smooth blue glazed paper is very good for this purpose, as it reduces the glare from the lamp.

Proofs.—When the engraving is finished, a proof may be taken in the following manner before blocking out the cut, that is, before the superfluous wood is cleared away;—rub down a little printers' ink on a slab till it is fine and smooth; take a little of this on a silk dabber, and carefully dab the block until sufficient ink is left upon the surface, without allowing any to sink below it. Lay a piece of India paper on the block with about two inches margin all round; on this place a thin smooth card; rub this over with the burnisher, taking care not to shift the card or paper.

Plugging.—If a slip or mistake occurs in a woodcut, it may be remedied by the insertion of a plug. A hole must be drilled in the block; if the error is a small one the hole need not be deep, but if a large piece has to be inserted it must be deeper in proportion. A plug is cut, of a round taper shape; the small end is inserted in the hole, and the plug is driven down, without, however, using too much force. The top of the plug must then be cut off, and carefully brought to a smooth surface, level with the rest of the block; if this is not done, the plug will be visible on the print. If the error to be remedied happens to be in a long line, a hole must be drilled at each end, and the wood between the two holes removed by small chisels, the hollow space being filled up in a similar way to that already described.

ETCHING.

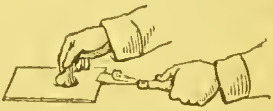
The apparatus consists of copper plates, etching needles, hand-rest, etching-ground, dabber, oil-rubber, rotten-stone, smoking taper, engraver's shade, bordering wax, stopping-out varnish, tracing-paper, and aquafortis.

Ground.—The ground is composed of equal parts of asphaltum, Burgundy-pitch, and beeswax; place them in an earthen pipkin in an oven, and melt. The mass must be kept stirred until well incorporated. Pour the mixture into a basin of cold water, and, when nearly cold, press and roll with the hand until all the water is discharged, then make into a ball. Procure a piece of worn silk, without holes; double it; place the ball therein, and tie up the ends with packthread, taking care that the double silk reaches well and tightly over the ball; cut off the surplus silk, and let the knot remain for a hand-hold.

Dabber.—Take a piece of silk, twice the size of that for the ground ball; double it; place in it a ball of coarse wool well picked out, about the size of a small apple; tie it up in the same way as the ball for the ground, and it is ready for use.

Oil-rubber.—An oil-rubber is made from a strip of woollen cloth, about 2 inches wide, rolled up tightly, and bound over with packthread or thin tape. With a sharp knife cut off one end, avoiding the string, so that the surface may be quite flat. This is used

Fig. 20.



for taking out stains, or polishing the plate, as in Fig. 20.

Rotten-stone. — Take a piece of fine flannel, rather less than the silk which covers the etching-ground ball; double it; place on it a small quantity of rotten-stone, in powder, which tie up in a bag. A small portion of fine whiting in the lump should be also kept at hand.

Smoking Taper, or Lamp.—For small plates, procure a wax taper; uncoil it by degrees before the fire until it is all equally pliant; double it up in about six lengths; give it one twist while warm, and turn it a few times before the fire, that the pieces of taper may adhere to each other; melt the wax at one end, so that the wick is exposed; see that all the cotton ends will light freely; care should be taken to extinguish the cotton, or it will revive with the least draught, and may become dangerous. For large plates it is preferable to use an ordinary oil lamp mounted on gimbals; this obviates the inconvenience occasioned by the dripping of the tapers.

Bordering Wax.—3 oz. rosin, 2 oz. beeswax, and such a quantity of sweet oil as will soften the mixture to fancy. Procure an earthen pipkin; place in the bottom ½ oz. or more of sweet oil; add the rosin and beeswax, broken in small pieces; when melted, work the ingredients well together with a stick until thoroughly incorporated; then pour into a basin of cold water; as it gets cold, work it well with the hands by pulling out into lengths and doubling it together again; the more it is worked the better it will be for use. Should it turn out brittle, return it broken to the pipkin, and add more oil; work it well together as before, pour it into water, and work it again with the hands.

Engraver's Shade.—Bend a piece of wire into a half-circle; bind it together with waxed string; lay it on tissue paper; cut away all but ½ inch round the wire: cover that ½ inch with paste, and turn it over the wire; when dry the shade is complete. Fasten a light string to the centre of the half-circle, and suspend it from the window-latch when in use. This shade must be placed in a forward position, sloping before the plate, and the white light it produces will enable the engraver to see the lines made by the etching needle. An equally effective shade may be made by covering a light square wire frame with tissue paper, and supporting it with two struts. This frame can be made to rest at any angle, upon the table immediately in front of the work.

Hand-Rest.—Any flat and thin piece of wood will answer the purpose, which is to keep the hand clear of the plate whilst at work. A good hand-rest may be made of a thin board raised above the work upon side pieces of such a height as to allow the plate to be freely moved underneath the board. The front edge of the board may be faced with a strip of steel planed true, when it serves as a straight-edge. This arrangement will be found extremely handy.

Stopping-out Varnish. — Turpentine varnish is superior, for several reasons, to Brunswick black.

Turpentine Varnish. — Break small pieces of rosin into a phial; pour over spirits of turpentine to about twice the height of the rosin. Place the bottle in a small saucepan of water on the hob, near enough to the fire to make and keep the water hot; place a cork lightly in the mouth of the bottle, as the mixture will require to be shaken occasionally. Pour a small portion of this mixture into a small pot, with a little lampblack added to give it a colour, and well mixed. This last is necessary to prevent lumps; it may be done by working the mixture well together with the camel-hair pencil. This is a good stopping-out varnish. With this varnish go over the border or margin of your plate; do this when about to put it away, and the varnish will become hard by being left a night to set. When biting-in again, go over the margin, using the same brush and mixture. It can always be worked up by adding a little turpentine. When it is set so hard that the finger may be placed on it without sticking, it is time to make up the wall or border of wax to hold the aquafortis.

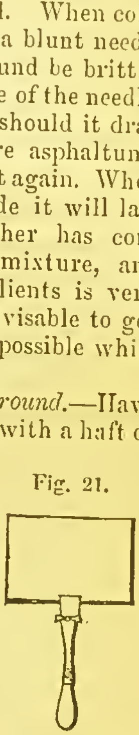
Aquafortis.—Procure three half-pint bottles with glass stoppers, and two pint earthen jugs with spouts. Place ½ lb. of nitric acid in bottle No. 1. Pour into bottle No. 2 rather less than the fourth of the nitric acid; fill the bottle ¾ full of water; slowly pass it into one of your pint jugs, and back again to the bottle, to mix it well. In bottle No. 3 put one-half of the remaining nitric acid; water it as before; see that the nitric acid in bottle No 1 is well stoppered, and cover it with a piece of old glove.

Tracing and Tracing Paper.—Tracing can be conveniently effected by using sheets of transparent gelatine, similar to that made for Heliotype purposes, and placing it over the drawing, which can be seen clearly through the gelatine. Trace with a sharp etching-needle, taking care to remove the burr from the lines with the thumb-nail as the work proceeds. When finished, fill in with fine powdered Brunswick black, entirely free from grease, or powdered red chalk, reverse on to the plate, and rub the lines with a burnisher. Tracing paper of various qualities may be readily purchased. But in case of necessity, very good tracing paper may be made by saturating, with a camel-hair pencil, the finest tissue paper with the following mixture:—½ oz. Canada balsam to ¼ oz. spirits of turpentine; shake well together in a 2-oz. bottle. When covered with the mixture, hang the paper on a line to dry; then wash in like manner the other side. Place your drawing on a tracing board—a piece of soft planed deal; lay the tracing paper over it; fasten down with brass-headed points, not through the drawing, but close to it, so that the pressure of the brass head secures both the drawing and tracing paper from moving. Go carefully over all the lines of your drawing with an H pencil, occasionally placing a piece of white paper between the drawing and the tracing paper to ascertain that no lines on the drawing have escaped attention.

Transferring Paper.—This is made as follows:—Take half a sheet of very fine bank-post paper · lay it on a clean place, and rub it well with the scrapings of red chalk with a small piece of sponge. Apply the chalk until the paper is all of one colour; then, with a piece of clean old muslin, rub the greater part of the colour from the surface. The colour may be renewed occasionally as the markings become faint.

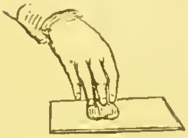
Testing the Ground.—Heat one corner of your plate, and rub over it the ground in a thin and even surface. Next apply your dabber, to make a yet more equal distribution of the ground. When cold, mark over it with rather a blunt needle (No. 3). Should the ground be brittle, and crack with the passage of the needle, add to it more beeswax; should it drag with the needle, add more asphaltum; the ground will easily melt again. When a ball is satisfactorily made it will last a long time. The weather has considerable effect on the mixture, and the quality of the ingredients is very important, so that it is advisable to get the ground as perfect as possible while the melting pot is in use.

Fig. 21.



Heating the Plate for Ground.—Have a small hand-vice, Fig. 21, with a haft of wood to resist the passage of heat to the hand. If the plate is stained or discoloured, the mark must be removed with the oil-rubber with a little rotten-stone and oil, polished off with a bit of old muslin powdered with whiting, care being taken that no dust remains on the plate. Screw the vice on the long side of the copper plate with a slight hold, covering the part grasped by the jaws of the vice with a small piece of paper to prevent injury to the surface. Heating may be performed by burning paper under the back of the plate; but a stove or clear fire is preferable, and a couple of spirit lamps with rests for the corners of the plate, the best plan of all. Be careful not to overheat the plate. If the surface becomes discoloured, the plate is overhot; as a test, turn it over and spit on the back; if the moisture jumps off, the plate is sufficiently hot; should it hiss and remain on the plate, more heat must be obtained. A piece of canvas, rather larger than the plate, should be warmed by laying it before the fire during the heating process; place it on the table, and lay upon it the plate retained in the vice. Now pass the ball of ground, Fig. 22, over it backwards and forwards until the plate is covered, spreading the ground as evenly and thinly as possible. Use the dabber with a quick action, pressing it down and plucking it up. If the ground does not distribute itself easily, burn paper under the plate as before until it shines all over, being cautious that the ashes of the paper do not settle on the surface; dab on again, decreasing the pressure, but not the speed of action, until the surface is all over alike.

Fig. 22.



Smoking the Plate.—Have the taper ready, and a single taper or candle to take the light from; the surface of the plate being perfectly covered, it may be as well to renew the heat in the plate, by a paper burnt under the back until the surface shines, taking the same precautions as before. Hold the plate in the left hand, with the face downward; light the smoking taper, Fig. 23, at the same time, having all the wicks burning; pass it rather quickly round the margin, and by degrees towards the centre, using a fluttering action with the hand, Fig. 24; smoke on until the whole surface is of a dark colour, keeping the taper at such a distance from the plate that the burning cotton may have no chance of touching it, although the flame spreads over it. Another way is to suspend the plate, if of large size, overhead, and smoke with the oil lamp. When the surface is all black alike, and no sooty marks are to be seen on the working part of the plate, the ground is fit for use. Take the plate, face downwards, to some convenient place, and pour cold water over the back, Fig. 25, holding the plate in a sloping position, the vice up. This last process produces a stronger and harder surface than could be obtained if the plate were left gradually to cool. Now place the plate face downwards, supported on one side by the screw of the vice, Fig. 26. Clean the smoke from the back, and let it remain until quite cold. Some difficulty may be found in laying the first ground with success, but with a little practice this is surmounted.

Fig. 23.

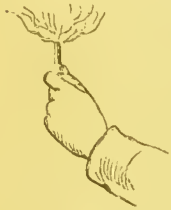


Fig. 24.

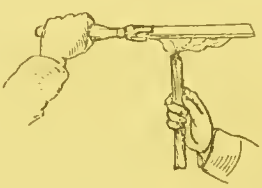


Fig. 25.

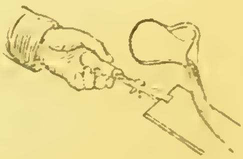
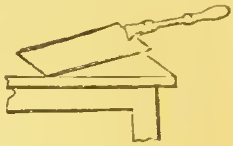


Fig. 26.

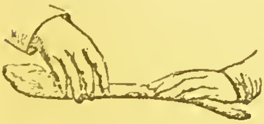


Transferring.—In the absence of an etching board, place the copper plate on a thick piece of brown paper larger than the plate; make two ribs of the same paper, doubled four or more times, and about an inch wide; place them at each end of the plate on the brown paper, and fasten them with sealing wax; these ribs serve as shoulders for the rest to lay on, which will prevent the hand from touching the work. Now cut the tracing paper to the size of the plate, having ruled the margin line if one is required. Place the tracing reversed; that is, with the pencil side to the plate. Fix it with pieces of soft wax round the border, leaving open the bottom to admit the transfer paper, which introduce with the chalk side next to the plate; the upper side of the paper must be kept clean, that the pencil-lines on the tracing paper may be seen. With an H H pencil, cut sharp and short, go over all the lines of the tracing with rather an upright hand and a strong pressure; the upper side of the tracing paper will show whether all the lines have been traced; look sideways at the work, and the black-lead marks will be perceptible. Before advancing far in the transfer, lift up the bottom of the tracing to ascertain if the lines are of sufficient strength; if not, apply more red chalk to the transfer paper. When the transfer is nearly completed, do not take off the whole of the paper, but let the top part remain fixed. Then lift up the tracing, and if any part of it has been neglected, it can again be fixed down, and the omission rectified.

Etching.—Commence with a fine-pointed needle, No. 1, and go carefully over the outline, not making much impression on the copper, but sufficient to remove the ground; with the same point go over all the lighter parts, increasing the pressure, so as to make a slight indentation on the plate. No. 2 point may now be used to go over the lighter shade, with an increased weight of hand. No. 2 point will answer for the darker shades by making the lines nearer together and increasing the pressure. Interline parts that require extra colour with No. 1 point; the etching may be worked at for a considerable time by interlining and dotting. If there are any marks to expunge, dip a pointed camel-hair pencil into the turpentine bottle, and with its point work up some of the ground on the margin of the plate, and therewith stop out the objectionable marks. When set, it will resist the aquafortis.

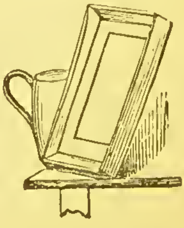
Bordering the Plate.—In cold weather the wax will be too hard to roll out with the hand; in that case it must be placed in moderately warm water until it becomes pliable; then pull and roll it out, Fig. 27, to about the thickness of a small walking-stick; slightly grease the point of the thumb and two forefingers with mutton fat; press the roll of wax flat, and place it on the border of the plate with the edge to the varnish, taking great care that the bordering wax does not go off the varnish. At the parts intended to be the darkest corner of the plate, pinch out the wax border, that the height of the wall may be increased at that corner where the spout is to be formed with the wax to prevent spilling the aquafortis in pouring it off.

Fig. 27.



Biting-in.—Lay the plate flat on a piece of canvas larger than the plate, as a protection from any splashings that may be made. Place the spout of the plate in front for the convenience of pouring off. Pour a little water over the plate to see if there are any leaks in your border; if there are any, pour off the water; let the plate dry, particularly in the defective part; then press down the outer edge of the wax with a piece of wood. Leaks can also be found without using water by holding the plate up to the light and looking at the edge, when the smallest pin-hole will be immediately detected. Have two or three small wedges, to be used for tilting the plate should the acid not lay even. When the border is sound, pour off the water; then cover the surface of the plate with the aquafortis from No. 2 bottle. If, in the course of half a minute, the etching on the plate should assume a light-grey coating, the mixture is good; but if it should throw up bubbles, it is over strong, and more water must be added but not on the plate. The mixture must be placed in the jug, then in the bottle, and afterwards returned to the plate. Should the lines on the plate remain as bright copper after the acid has been on half a minute, it is not strong enough, and some aquafortis out of bottle No. 3 must be added. When the mixture on the lines does not produce a foam, but the plate continues of a grey, frosty appearance, the process is going on well. The power of biting-in correctly depends on the experience in using the acid. With a soft camel-hair pencil, lightly remove the frosty appearance, taking care that the quill does not touch the ground. Should any part of the ground break up by the lines becoming united, pour off the acid carefully into the jug.

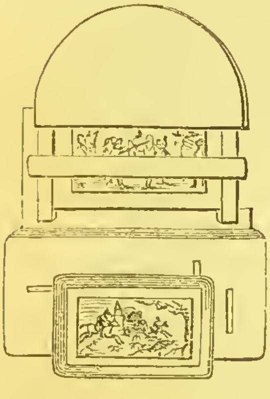
Fig. 28.



Lay the plate again on the flat, and cover it with water from the other jug, moving it gently with the camel hair pencil, which place at once in a water jug when taken from the acid, or it will soon be destroyed. Throw away the wash water from the plate. When the first biting is completed set the plate up endways to dry, Fig. 28.

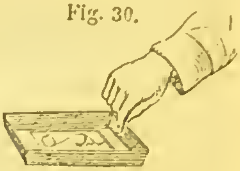
Second Biting.—When the plate is perfectly dry, take off with a blunt point covered with silk and dipped in turps a spot of ground in the lighter part to ascertain if the acid has made sufficient indentation. If it has, work up the stopping-out varnish with a camel-hair pencil, and with it cover all the parts intended to remain light; elevate the rest, Fig. 29, so as not to press the border wax. When the stopping out varnish is dry, which may be ascertained by placing the finger on it (if it does not stick, it is dry), put on the same aquafortis (bottle No. 2), and let it remain until you observe the ground giving way; then pour off the acid, and wash well as before. Put the plate to drain. Should it be required, more biting may be done; the process is the same.

Fig. 29.



Cleaning Off.—Great care must be taken that the plate is perfectly dry; if it is not, it may be placed before the fire, but not close enough to melt the wax. Having carefully wiped the canvas, lay the plate a little more than half-way upon it, so that the balance remains upon the table. Apply a lighted taper, or a folded paper match, progressively under the wax; pull up the wax, Fig. 30, as the warmth proceeds; a very slight warmth answers the purpose. By removing the wax with a knife you are liable to injure the margin, which is difficult to remedy. Should any of the wax adhere to the plate, remove it by using a piece of wood cut in the shape of a chisel. Fix the vice on the same place as when laying on the ground. Rub the plate over with turps, taking care to go over every part; hold the plate up by the vice; heat the back with burning paper as before, until the ground varnish and tallow are melted. Rub off with a soft rag. Should any smut remain, apply a little turpentine; withdraw the vice, and wash the spot it covered with turpentine. Rub the plate front, back, and sides with the rag. Dab the plate with the bag of rotten-stone; pour on it a little sweet oil; and polish the plate with the oil-rubber, using considerable up-and-down pressure; wipe the plate quite clean, and polish with fine whiting. Should the biting-in have succeeded, the plate is ready for the printer.

Fig. 30.

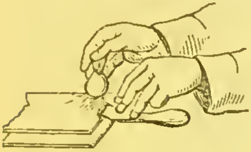


Dry Point.—The dry point may next be used. For this purpose the needle No. 3, well pointed, may be employed, as indenture must be made by pressure of the hand. For interlining the parts which are too weak, and uniting lines neglected in the etching, the dry point will be sufficient; but the pressure will leave a projection or burr on the plate, which must be carefully removed by the sharp scraper; should the plate require more than the dry point can accomplish, recourse must be had to re-biting.

Re-biting.—Heat the plate as before, but make one corner, the one with the least work in it, hotter than the other part. Prior to laying the ground, the plate should be polished with whiting, or with methylated spirit and aquafortis, using a piece of old muslin folded in the shape of a dabber, which will fill the etched lines, and prevent the new-laid ground from entering. Rub the ground on the hot corner, and with the dabber take the ground therefrom, and dab quickly over the other part until the whole surface is covered. All the parts but those wanting more colour may be stopped out as before; the border wax must again be used. Next follow the same process with the acid.

Re-etching.—This is the most certain method of finishing the plate. The ground must be laid as in the first instance, but using a greater body, and with the dabber, Fig. 31, rubbing it well into the lines, taking care that no whiting remains in the etching marks; for this process the plate should be merely washed with turpentine; a slight extra warmth and good dabbing will render the ground acid proof. The smoking is here dispensed with. Set up the ground, and work at the plate as in the first instance. Now use No. 3 sharp point, and interline the parts that should be darker and where greater strength is wanted, crossing the lines, not at right angles, but lozenge-ways. The plate, cleaned off as before directed, receiving a light oil rubbing with a little rotten-stone, and washed off with turpentine, may now be sent to the printer's, and a proof obtained. By repeating the re-etching, the plate may be worked up to the colour of a line engraving. In some of the darker parts a graver or lozenge-tool may be used; but it is rather dangerous in the hands of the uninitiated; as it is apt to slip, and make deep lines where none is wanted. Re-biting will produce any extra colour that may be wanted, with little more trouble and with greater safety.

Fig. 31.



Process avoiding Stopping-out.—For the first biting, ground and smoke the plate in the ordinary manner, then etch those parts only which are to be darkest, such as vigorous foreground in landscapes, and other deep work. Use no delicate lines at this stage; japan the back of the plate and the spot where the hand-vice was placed; use a photographer's tray as an acid bath, in which immerse the plate in nitric acid until the very black lines are bitten-in. Clean the plate, and take a proof. For the second biting, ground the plate again, and smoke it; the first lines will still clearly show. Draw all the work of a medium darkness, with a sharper point than that used for the first biting-in. Place the plate in the acid bath, and let it remain until the lines are of a moderate depth. Remove and clean the plate, and take a second proof. For the third biting, ground with transparent ground, and do not smoke it. Etch all the delicate work, keeping the lines close to each other, and using a sharper needle than before. This operation requires more care than the two previous ones, as the lines will not show very distinctly. This process is of great service for intricate work, in consequence of the facility it gives for introducing pale lines amongst the darker work, and a delicate background beyond the vigorous lines of the subject; whilst, by taking proofs after each biting, the progress of the work may be seen, and its correctness ensured. By covering the back and edges of the plate with japan varnish, the old and tedious process of banking up the sides with wax is avoided, and the plate may be plunged into the acid bath without any further risk or trouble.

General Instructions.—The following directions will relieve beginners from much trouble, and enable them to avoid many accidents to which engravers are liable:—When using the acid, slightly grease that part of the hand likely to come in contact with it, as a preventive to its making stains, which are not easily eradicated. When your border wax has done its duty, have it well washed in cold water, then warmed before the fire, pulled out and pressed together again, as the more frequently that is done the more pliable the wax will be for future use. As your aquafortis will become reduced in strength by exposure to the air, it becomes necessary to add a portion of No. 3 bottle to that of No. 2, and a small quantity of No. 1 bottle to No. 3, No. 1 bottle containing the undilute acid. When making a point to an etching needle, work the point round, as, should there be any flat side to the point, it will bite the copper, and prevent the freedom of hand required to give spirit to the etching. The burnisher will soften down any part of the etching that appears harsh or crude, by gently passing it over the parts to be reduced in colour. The shade must be between the plate and the light, in order to be able to see the marks of the burnisher; fine charcoal and oil will remove these marks, and the oil-rubber will clear away the charcoal marks. The charcoal can be obtained at a coppersmith's or plate-printer's. If a burnisher is good at first, it never requires alteration. The scraper must be occasionally sharpened.

Soft Ground.—Take half a ball of hard ground, mixed as described under the head *Etching Ground;* to that add a piece of mutton suet. Melt them well together, observing that the ingredients must be thoroughly incorporated; then pour into cold water, and use it as before directed.

Laying the Ground.—The process is exactly the same as in laying the etching ground, with this difference, that the plate does not require so great a heat. Smoke the plate the same as in laying etching ground. The ground must be spread as thinly as possible, to cover the plate and bear smoking. The surface of the plate must be alike all over, and quite bright or shining. If any part but the edges appears sooty, it must be cleared off, and the plate polished, as described for etching, and laid again. A good ground may be made at the first melting, but that can scarcely be expected. It may be as well to test the quality of the mixture before laying a whole ground. To this end, heat a small portion of the plate; lay on the ground; smoke it; and let it get quite cold. Obtain some of the finest tissue paper, of very even texture. Place a piece of the paper on the patch of ground laid, and, with a fine-pointed H pencil, make a slight sketch—a bit of foliage, for instance; the paper should slightly stick to the plate; when carefully raised by the two bottom corners, the back of it should clearly show every line made on its surface, only darker. Should the sketch on the copper look as if it was dotted all over, the mixture of ground will do. Should the ground adhere to the paper, like marks with pen and ink, the ground must be melted, with an addition of hard ground; and if even the softest marks of the pencil do not pull the ground from the plate, the ground must be remelted and remixed until it is fit for work. As the temperature has great effect on this ground, that which will answer for summer will not do for winter, so it may be as well to make two or three mixtures, and number them according to their several degrees of hardness. Having succeeded in mixing the ground, take a piece of tissue paper twice the size of the plate. Place the plate in the centre, and with a black-lead pencil draw a line all round it. Make the same mark on the other side; then lay the ground as described. When cold, wipe the back and edges before taking off the hand-vice. This ground being very tender, care must be taken not to touch the face of the plate.

Drawing.—The drawing is to be made upon the square marked on the paper. If it is intended to copy a subject, the same process as in transferring for the hard-ground etching is used; only, instead of transferring the red lines on to the plate, they must be made within the square marked on the paper. Take care that the tracing is reversed. If it is intended to draw on the plate without copy, lightly make the design on the square marked with fine-pointed red chalk. Should the subject be figures, everything must be drawn to the left hand, or reversed. Fold a silk handkerchief in four; lay it flat and smooth on the table; place on it the paper, with the chalk sketch downwards. Then, with great care, lay the plate, face down, exactly on the square mark of the paper; fold over the back the surplus paper, and fix the sides with four thin spots of sealing wax near the corners; be sure not to move the plate on the silk. Take up the plate carefully, and place it for work. Use a hand-rest, as in etching, and a hard-pencil, H H, on the places you wish to be dark. In soft-ground engraving, the drawing must be finished the day it is commenced; the mechanical part of the work may be delayed. When the drawing is finished, pull up the paper by the two bottom corners. Varnish the border down the same as in etching. The acid used must be much stronger; the border wax higher and broader in the spout, as you may perhaps have to pour off suddenly.

Biting-in.—In biting-in, pour off the acid when the ground begins to break up; that is, coming up in patches. During the biting-in, the soft camel-hair pencil may be used, but very tenderly. Wash well off with cold water, and place the plate to dry. For cleaning, see *Etching.* Should the plate require more finishing, have recourse to the hard ground without smoking.

AQUA-TINTA ENGRAVING.—This was formerly resorted to where the object was to produce a plate, the impressions from which were to be coloured. It is recognised by its similarity to Indian ink or sepia drawing; for, in working the plate at press, black and brown inks are used indifferently, as the artist or publisher may direct. Rosin forms the ground in this method of engraving.

Aqua-tinta Ground.—Break some of the best white rosin into pieces, put into a bottle with spirits of wine, and shake occasionally until the rosin is dissolved. The bottles must have corks, not glass stoppers. Have two other bottles ready; mark the bottles 1, 2, 3. No. 1 is the bottle in which the rosin is placed. Pour a third of No. 1 into No. 2, and nearly fill it with spirits of wine. Pour into No. 3 rather less of the mixture from No. 1, and nearly fill it with spirits of wine. These bottles must be occasionally shaken, and their contents allowed to settle well before use. The contents of the three bottles must be so mixed that they are one under the other in strength, as the size of the grain to be laid on the plate depends on the quantity of rosin each mixture contains. The more rosin the larger the grain. The spirits should be entirely free from water.

Testing the Spirits.—Place a small quantity of gunpowder in a silver spoon; pour over it some of the spirit; light the spirit, and let it burn to the powder. If the powder takes fire and explodes, the spirit is good, and fit for use. Should it remain in the bottom of the spoon, black and wet, the spirit has been adulterated with water, and is not fit for the purpose.

Trial of Aqua-tinta Ground.—Have a tin trough about 2 in. wide, and rather longer than the plate, with a convenient spout at one end; the trough is to act as a receiver of the spirit when poured over the plate; the spout to return it to the bottle.

Laying the Ground.—Polish the plate well, as before directed. Place it at a slight slope, the tin trough under the lower edge to receive the spare mixture. As a trial of the ground, pour the liquid from each bottle, and make a small patch in different places at the bottom of the plate. When the liquid has run off into the tin trough, lay the plate flat, and with a piece of rag wipe the lower edge. Take a magnifying glass, and look at the grains deposited on the copper. Having poured the spirit from the trough to bottle No. 1, make choice of the grain most likely to suit the work; if neither of the three should, mix the large grain and the small together until it does, letting the mixture settle well before it is used. Remove the trial spots; polish the plate well, and place it as directed for trial with the side intended for the foreground next to the tin trough. Pour the mixture along the top of the plate, from one end to the other, until the whole of the surface is covered. As soon as the spirit has run into the tin, lay the plate flat; the sooner it is laid flat the rounder will be the setting of the grain; the longer the plate remains on the slope the more elongated the deposit of rosin will become, which for some sort of work will answer better than round: such as broken rock, waterfalls. In most cases it is advisable to make a very fine etching of the subject intended to be placed on the plate prior to laying the aqua-tinta ground; in the end it will save time. The etching must be very light, otherwise the aqua-tinta ground will hang round the lines, and form a ray of light. Should the etching be strong, it will require to be filled up with wax, and polished off before laying the ground. Engravers send the plate to the printer's to have it filled up with ink, which is the best method. If obliged to use wax, heat the plate rather above what is required for the etching ground; the surface is then wiped off, and polished with the soft part of the hand slightly rubbed with whiting.

Stopping-out the Lights.—Place on the left side a small looking-glass in a leaning-forward position; lay before it the drawing intended to be worked from, with the base or foreground towards the bottom of the glass; you will then see the subject reversed in the glass. Go over the margin as directed in the head Etching. For this a camel-hair pencil and the same pot of varnish, with a little more lampblack added, and well worked together, should be used. Stop out all the white lights seen in the drawing. By the time this is done, the varnish on the margin will be dry or set; if not, the plate must remain until it is. Go over the margin again with the same varnish, and let that set hard. Place your border wax as before directed, making the spout rather larger, that you may be enabled to pour off the acid quickly if necessary. Use the same aquafortis as for etching, but the strength somewhat increased, as it must remain on the plate a much shorter time. Lay the plate an inch or so over the front of the table, with a piece of canvas underneath, having small wedges of wood ready to be used should the acid not float evenly.

First Lights.—Pour on the acid rather quickly, running it from the bottle to the jug, then on to the plate; another jug, having been filled with cold water, should be kept ready for washing off. When the acid has entirely covered the plate, the surface should immediately assume a frosty appearance, but not come up in bladders. Little more than a minute may be enough for the acid to remain on the plate; pour it into the jug as quickly as you can without spilling it; immediately wash off with cold water; have a receiver for the wash-water, as it must be thrown away.

Second Lights.—Dry the surface of the plate, and, should any spots of moisture remain on the surface, carefully take them up with blotting paper. Now, with the same varnish, stop out all the second lights. To prevent injury to the border, place two blocks or old books under the ends of your rest.

Third Lights.—When the second stopping-out is set, put the plate through the same process with the same acid. Again dry the plate, and stop out the third light parts; when set, apply the acid, but let it remain on rather longer; wash as before directed. As all the flat tints are now laid, it only requires the very dark ones. Ascertain, with a magnifying glass, if the spots of rosin remain on the plate; if so, it will bear biting again. Should the ground remain sound enough to stand another application of the nitric acid, you must prepare a mixture called touching stuff.

Touching Stuff.—Burn a good-sized cork to ashes; take some treacle and add as much ivory black as will make the mixture a dark colour by the addition of a small quantity of sheep- or ox-gall; it works almost as free as the varnish. Make the composition into a ball, a small quantity to be used with water when required. Again lay the plate for work. Paint over all parts that are required to be very dark, such as projecting foliage, and all sharp shadows, with the touching stuff, loading all the touches with as much of the mixture as can be placed on them. When the touching stuff is dry, mix some turpentine varnish, slightly coloured with lampblack, and with a larger brush go over the whole of the plate. When this last varnish is set, pour on some very weak acid and water; the former washings of the plate will do. With the soft camel-hair pencil used for the acid, work up the touching stuff until the whole comes off; then wash the plate clean with cold water, and again apply the acid. For this last biting the acid may remain on the plate as long as the ground will stand. This may be ascertained by clearing the plate with the camel-hair pencil, and using the magnifying glass. The plate must now be cleaned, and remove the border wax as before described. On this tint the oil-rubber should be very carefully used. The plate being quite clean, and placed under the shade, it will be found that the tints or bitings are rather sharper against each other than is required. The burnisher will remove this by rubbing the parts which are to be reduced in colour. The parts to be burnished should be slightly touched with the oil-rubber. The use of the burnisher requires some skill, which can only be acquired by practice. The scraper is useful for bringing out sharp lights, and modulating the darker parts. If the first ground is not satisfactory, the plate must be polished, and another ground laid. The second ground must contain more rosin than the first; bordering, biting, and stopping-out, as before. The plate should be sent for proof before the second ground is laid. The proof will show where increase and where reduction of colour is required. The burnisher will reduce; the increase can only be had by laying another ground.

Ground to Etch on.—Mix a small quantity of turpentine varnish with turpentine slightly coloured with black, but only sufficiently so as to render the lines made by the needle perceptible. With this thin varnish, and a good-sized camel-hair brush, go over the plate lengthways; when that is set, repeat the coating crossways; let it set, and lay it by for a night if convenient. The etching finished, border and bite as before directed, but with stronger acid.

General Instructions. — Great care must be taken while laying the ground that there is not much dust floating in the air; for, should the slightest particle of flock lodge on the plate whilst wet it will cause what is called an accident. Wherever the speck falls the rosin will corrode around it, forming a white spot on the ground where the acid has been applied. These accidents are of little consequence, unless they should happen on the sky. To do away with these light places, the chalk tool, or dotter, must be used; this is simply a bent graver. From pouring the ground mixture backwards and forwards, it is likely to become foul; it should then be passed through a double piece of clean muslin, and put away in a bottle to settle. The burnisher acts as principal in forming a good sky and background. As the action of the acid will leave all the tints with a sharp edge, they must be softened down with the burnisher. Every fresh aqua-tinta ground laid should be increased in the size of the grain, or the ground will become murky. To enrich and darken the foreground and foliage, etching over the parts with the etching ground above described is much the easiest method.

Rosin-ground Engraving.—This is well adapted to ornamental work, as great depth of colour can be obtained. The process is extremely simple. The best white rosin should be reduced to powder by pestle and mortar, then placed in fine double flannel, and tied up in a bag. The plate must be heated as in laying etching ground, and the rosin then powdered on the surface; lay the plate on a table, so as to leave both hands free. Take the bag of rosin in the right hand, and strike it against the left. The bag must be held some distance from the plate, which will force the powdered rosin to escape from the flannel bag, and, falling on the hot plate, will there fix itself in small spots, something similar to the aqua-tint deposit, but much more enduring. This produces very imperfect results, and causes dry-ground engravings to be looked on with disfavour. The stopping-out process is the same as in the aqua-tint. By repeating the process with the flannel bag, a positive black ground may be procured, as dark and more enduring than a mezzo-tinto ground, and it may be scraped on much in the same way.

Hamerton's Brush Process.—This process consists in the employment of a pigment which is strongly attacked by acid. Clean the plate thoroughly with whiting and turpentine. Remove the whiting by rubbing the plate with bread; after removing which do not allow the hands to touch the plate. Crush a soft pastel into fine powder; mix with a strong solution of white sugar. Add a solution of ox-gall, about equal in quantity to half the sugar solution. The pigment must be so mixed as to work rather freely, and draw a thin line with ease and precision. With a small, fine-pointed sable-hair brush, make the drawing on the plate, depending mainly upon lines, as with a pen; when this is completed, be careful not to let anything touch the plate, as the pigment dries slowly. Dissolve some ordinary etching ground in ether; hold the plate with a pneumatic holder, and pour the solution upon the plate till it makes a pool reaching the sides of the plate; move the plate gently from side to side, then pour the superfluous solution back into the bottle. Heat the plate gently over a spirit lamp, holding it about 12 inches above the flame, and taking care to evaporate the ether gradually, and not to allow it to catch fire. The ground will become transparent. Place the plate in a bath consisting of 100 grammes hydrochloric acid, 20 grammes chlorate of potash, 880 grammes water. The hydrochloric acid used should not be of a deep yellow colour; should not gives off fumes, and, when mixed with water, should have but a slight odour. Leave the plate in this bath $\frac{1}{4}$ hour, then brush the surface of the plate very gently with a feather. This will remove the pigment and the ether varnish over it, leaving the lines exposed to the acid. The copper between them will be perfectly protected. Leave the plate in the bath until bitten-in to the required depth, stopping out when necessary. The finer portions of the work may either be finished with the dry point, or in point etching; in the latter case using a transparent ground. If any erasing is necessary, it must be done with a scraper. If the pigment does not take on the plate, the copper may be slightly roughened by a short immersion in a weak nitric bath. Let the ether ground remain a night on the copper before heating it, which must be very carefully done.

HAMERTON'S NEGATIVE PROCESS.—This process avoids stopping-out altogether, and the progress of the work may be judged of with tolerable certainty. The ground is a solution of beeswax in turpentine. Decant the solution till no sediment remains; it should be perfectly fluid, and of a bright yellow colour. Add about one-sixth of its volume of japan varnish; this quantity will vary slightly according to the heat of the weather. If there is too much japan, the ground will be hard and brittle; if there is too little, it will not be strong enough to take smoke with safety. Clean the plate with engravers' emery paper, and place it in a bath of 100 grammes hydrochloric acid, 20 grammes chlorate of potash, 880 grammes water. When the plate darkens all over, it is a sign that there is no grease on it, and it is then ready to receive the ground. Pour on the ground as photographers pour collodion, and let it dry for 12 hours; apply a second coat of ground in the same manner, and smoke the plate immediately without waiting for it to dry. The ground should then be even and smooth, and ought to be used a few days after it is laid, as it hardens in time. If in haste to use the plate, the first coat of ground may be dried over a spirit lamp until it becomes transparent; cool the plate, and proceed as before described. The use of the two coats of ground is to prevent the smoke penetrating to the plate, and causing the ground to become detached in the acid bath. Should the ground be too hard, increase the proportion of the wax solution. Draw all the dark parts first; plunge the plate into a bath of nitric acid for half the time necessary to complete the biting. In temperate weather this would be half an hour; the first biting would, therefore, take about 15 minutes. Remove the plate, dry on blotting-paper, draw the next darkest lines where required, and replace the plate in the bath for a quarter of the total time. This process is repeated, and the plate, with the paler work, is replaced in the bath for one-eighth of the total time. The palest work of all is last drawn, and the plate is plunged into the bath for an eighth of the total time. Thus the plate will have had the darkest lines in acid the whole time required, the darker lines half the time, the pale lines a quarter, and the palest lines one-eighth of the time, as each biting-in has the advantage of those which preceded it. Finish with the dry point where required.

HAMERTON'S POSITIVE PROCESS.—By this process the work is distinctly seen during operation; black on a white or silvered ground, without any deceptive glitter, and exactly as it is to be seen in the print. Clean the copper plate, and rub it with a clean rag and a little cyanide of silver. Remove the superfluous cyanide with a clean rag, and the plate will be properly silvered. If the cyanide is too thick, add a little spirits of wine. If it is wished to make the silver of a dead white, slightly roughen the surface of the copper before silvering with fine emery paper, rubbed from right to left, or from left to right, of the way it is intended to work the plate. Use a white ground, made by dissolving white wax in ether—a saturated solution. Let it settle a few days; the clear part only is required, the milky portion at the bottom, being undissolved particles, are probably insoluble and useless. To apply this ground, hold the plate underneath with a pneumatic holder; pour the solution on the silvered side; move the plate gently but firmly from side to side, so that the solution may run to and fro; then pour all the superfluous ground back into the bottle. In finishing, move the plate more rapidly. Let the ground dry for 3 days. Apply a second coat in the same manner, and let it dry for 4 days in a quiet room, where it will not catch any dust. If the plate is dried by the heat of a spirit lamp, the ground will be transparent, but not of the dead white colour which is desirable. Paint the back and edges of the plate with japan varnish to protect them in the bath, which must be composed as follows:—20 grammes chlorate of potash, 100 grammes pure hydrochloric acid, 880 grammes water; or the same proportion in English weights. Warm the water, dissolve the chlorate of potash in it, then add the acid. Sketch the subject with some pale but decided water colour, red or yellow for example, using the point of a small camel-hair brush. This will remain visible whilst the plate is being etched, which must be done whilst it is in the bath; the acid will, of course, attack the needle, but this action keeps the needles sharp, and they are not costly tools. The bath should be formed in an oblong square piece of light wood, about 1½ inch thick, and larger than the well, which must be a square hole, a little larger than the plate, and about an inch deep. Cover the board and well with about six coats of japan, which protects the wood from the action of the acid, and the dark colour makes the plate look whiter from the contrast. A thin piece of wood, stained black, must be used as a hand-rest. Before using a new bath or well, dissolve a small piece each of copper and of zinc in it with acid. Lay the plate in the desired position, and fix it by pressing small pieces of modelling wax at the corners against the plate and the board. Etch with an ordinary strong sewing needle inserted in a holder. It must be sharp enough to scratch well through the silver, otherwise the line will not blacken at once. The wax ground permits the lines to enlarge slowly; thus there is a constant gradation in thickness from the first to the last lines; as the time of exposure diminishes, this property must be carefully attended to. Thus, if the subject requires only about 2 hours' work in etching, this must be spread over 5 hours' exposure in the bath, which is the time necessary to produce the darkest lines; other work can be carried on simultaneously, but this process cannot be hurried. If, however, the subject is elaborate, and requires more etching than can be finished in 5 hours, select for the first sitting various parts over the whole plate; clean and re-ground the plate; at the second sitting add work to that previously done, and so on until the plate is finished, so arranging the times as to work always at the same period of the operation on tones intended to be of the same depth. This process is acquired with a little practice. If necessary to efface, it may be done in the usual manner with scraper and charcoal; always re-silver before retouching, if retouching is required. For cleaning the plates, turpentine is usually employed, but shale-oil or petroleum is a better cleanser, and removes the japan varnish very rapidly, whereas turpentine dissolves it slowly.

Etching from Nature.—Etching is the only kind of engraving which can conveniently be done directly from nature. The choice of subjects is the most important point, as, although etching is admirably adapted for trees and vegetation in all its forms, and for picturesque buildings and animals, it is not so well suited for the representation of figures, or for other subjects which require delicate gradations of tones. For anything that can be expressed by lines, etching is very successful, but it is not easy of application to tones. In working from nature, the shading, in addition to giving the light and dark tints, should also be used to indicate the form and texture of the surface, the lines being drawn in a direction to indicate form as well as tint. Several plates, ready grounded, may be carried in a small grooved box to keep them apart; if only one plate is intended to be used, it can be carried between two light boards, but must not be allowed to touch them. This can be avoided by fixing small pieces of modelling wax at the corners of the plate. If intended to be etched on Hamerton's positive process, the drawing board, with the well in it, must be taken, and the necessary hydrochloric acid and chlorate of potash in two stoppered bottles. These can be mixed with water when required. Dry point is frequently used in the finishing of etched plates. The dry point is an ordinary steel etching needle, sharpened in a peculiar manner with a sharp rounded cutting edge, and used without either etching ground or acid bath. By using this tool on the bare copper, a burr is raised, which catches the ink, and in printing gives the desired effect of a line with a delicate gradation. The more perpendicular the needle is held the less burr there will be raised; by inclining the hand to the right the burr will be increased, if the pressure on the tool remains the same. Practice enables an etcher to regulate the pressure on the tool; but if the pressure used has raised too strong a burr, it can be partially or entirely removed by using a sharp scraper worked at right angles to the line. If it is desired to see the progress of the work, rub a mixture of tallow and lampblack over the plate; remove what is superfluous with a soft rag; the effect of the etching can then be fairly judged of. Dry point etching can now be made to give a large number of impressions, by having the plate protected with a coating of steel applied by galvanism. To efface faulty work, use sand-papers of several degrees of coarseness; the coarsest first, then the scraper; finally, rub over with willow charcoal and olive oil. This leaves the plate fit to be etched upon; if, however, it should be hollowed out by this process, mark the spot on the back of the plate by means of callipers. Lay the face of the plate on a block of polished steel, and give it two or three blows on the back with a rounded hammer. The engravers' copper planers will do this work with more precision and skill than can easily be acquired by ordinary etchers. A passage that has been over-bitten may be easily reduced by being rubbed with willow charcoal and olive oil, which merely reduces the copper without injuring the lines, except the very pale ones; these must be etched over again. It is better to have the plate over-bitten than not enough, as the former is more easily remedied than the latter.

Stippling is also executed on the etching ground by dots instead of lines made with the etching needle, which, according to the intensity of the shadow to be represented, are made thicker and closer. The work is then bit-in.

Etching on Steel is executed much in

the same way as in the process on copper. The plate is bedded on common glaziers' putty, and a ground of Brunswick black, or wax, is laid in the usual way, through which the needle scratches. It is then bitten-in in the way above described.

Etching on Cast Iron.—Use a solution of common salt and sulphate of copper for the biting-in.

Etching on Steel or Iron.—Take sulphate of copper, sulphate of alumina, and muriate of soda, of each 2 dr., and strong acetic acid 1½ oz., mixed together. First smear the part intended to be etched with yellow soap, and write with a quill pen without a *split.*

FIREWORKS.

The three prime materials of the art of pyrotechny are nitre, sulphur, and charcoal, along with filings of iron, steel, copper, and zinc, and rosin, camphor, lycopodium, &c. Gunpowder is used either in grain, half crushed, or finely ground, for different purposes. The longer the iron filings, the brighter red and white sparks they give ; those being preferred which are made with a coarse file and quite free from rust. Steel filings and cast-iron borings contain carbon, and afford a very brilliant fire, with wavy radiations. Copper filings give a greenish tint to flame ; those of zinc, a fine blue colour ; the sulphide of antimony gives a less greenish blue than zinc, but with much smoke ; amber affords a yellow fire, as well as colophony and common salt, but the last must be very dry. Lampblack produces a very red colour with gunpowder, and a pink with nitre in excess. It serves for making golden showers. The yellow sand, or glistening mica, communicates to fireworks golden radiations. Verdigris imparts a pale green ; sulphate of copper and sal ammoniac, a palm-tree green. Camphor yields a very white flame and aromatic fumes, which mask the bad smell of other substances. Benzoin and storax are used also on account of their agreeable odour. Lycopodium burns with a rose colour and a magnificent flame.

Iron tools must never be used in making fireworks of any kind, as they are liable to throw out sparks when striking against a hard stony substance, besides which the sulphur used would injure the iron. Brass tools may be used, but copper tools are preferable.

ROCKETS.—Of all fireworks, rockets are among the most noble and effective. The ingredients for these, the apparatus employed, and the detail of the manufacture of them may be considered the foundation of all fireworks, and to make them well involves the same principles, and requires the same caution, as making all others.

Sizes.—The size of rockets is indicated by ounces or pounds ; thus we say, an eight-ounce rocket, a pound rocket, and so on; by this expression it is not meant that the rockets weigh so much as their name indicates, but that the bore or cavity will just suffer a leaden bullet of that weight to pass down them. For example, a pound rocket will admit a leaden bullet that weighs a pound. Rockets may be made of any size from 1 oz. up to 50 or more pounds.

Cases or Cartridges.—These may be made of any kind of stiff thick paper, either cartridge paper or what is equally good and much cheaper, namely, common bag-cap paper. To roll up the cases you must have a smooth round ruler, or, as it is called, a former, exactly the size of the cavity of the rocket, and 10 or 12 times as long. Lay a sheet of the paper upon a slab of slate, marble, or glass, and paste 4 or 5 in. along the end of it, leaving the rest of the sheet of paper without paste ; then roll it smoothly over the former, dry end first, until the whole is rolled up, when of course the paste will stick and a thin case will be formed. Keep rolling it along the slab with the hands, in the same way as a rolling-pin is used, for two or three minutes, until the various folds of the paper set close and tight to each other ; then put on another sheet in the same way, and so on, till the case is thick enough. This is known by the measurement across it. If the former without the case measures five parts, when the case is upon it they must measure together eight parts. That is, the paper must be rolled on till it forms a case, the thickness of the sides of which are a trifle more than one-third of the thickness of the former. The length of the rocket-case, and consequently the width that the sheets of brown paper are to be cut before pasting, varies with the size of the rockets; in small rockets the length of the case may be six times the diameter, in larger rockets four or five times is sufficient. When the case has proceeded thus far, it is to be choked while yet damp, that is, to be contracted in diameter near one end, and for this purpose a simple contrivance is requisite, called a choking cord, and also the former is made with a hole drilled at one end, and a second joint made to fit on by means of a wire projecting at one end of it, and which fits into the hole of the former, Fig. 32. To choke the case, draw the former partly out, until you can see about 1 inch of the inner cavity of the case, then put on the second joint (the wire of which fits into the hole of the former), and pass this on until its end is about ½ inch within the case, leaving a space of about ½ inch between the two joints occupied by the wire alone. Then going to an apparatus similar to that shown in Fig. 33, turn the cord once round the case where the cavity is, put the foot upon the treadle, which tightens the cord and squeezes the paper case at the point required. That it may squeeze it equally and neatly on all sides, the case should be held in the hands and moved up and down upon the cord until the operator sees that it is sufficiently and properly compressed. Let it be observed that although the choking apparatus used by the firework maker is represented and above alluded to, yet to the amateur it is by no means necessary. What will do quite as well is a thin cord fastened at one end to a staple in the wall, and by the other tied round the waist of the operator; as he may lean back, of course the cord would be tightened, and the desired purpose accomplished. When the case is sufficiently compressed, it is tied with two or three turns of strong string. The case is now complete, except that the part of it where it is choked is perhaps rather rough and uneven inside; this must be compressed down, for much of the effect of the rocket will depend upon the perfect regularity on this part, as it is through the hole left by the wire in the middle of the choke that the fire is afterwards to issue. To compress this part properly a mould is necessary.

Fig 32.

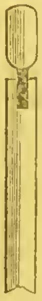
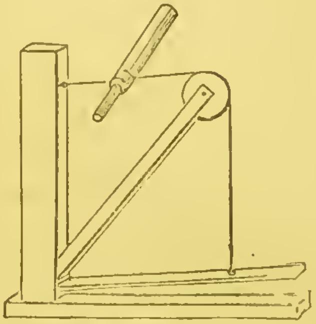


Fig. 33.



The Rocket Mould is represented in Fig. 34. It consists of a solid foot of wood; upon the centre of this stands a short cylinder about ½ inch high, and exactly of the size of the mould, to be placed over it, as afterwards described; this short cylinder has a shoulder above, and terminates in a round top. Out of the middle of the top is a tapering thick brass wire, projecting some inches upwards, as is seen in Fig. 35. The whole is so arranged, that when one of the newly-

Fig. 34.

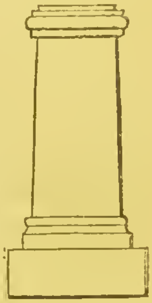
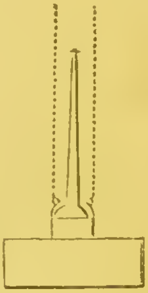
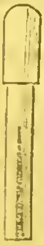


Fig. 35.



made cases is put upon the wire and forced down, the wire fills up the choke-hole, the round top fits into the small parts of the case below the choke, the shoulder of the cylinder bears the extreme end of the case, and the short cylinder agrees in size with the outsides of the case. There fits over this (case and all) a strong wooden or metal tube; so that it is seen that there is no cavity anywhere, except the inside of the rocket case, and even in this a thick wire runs up to nearly the top of that part of the case where the composition is rammed, or nearly $\frac{2}{3}$ of the whole case from the choke upwards. The wire above mentioned is called the piercer. All rockets must be placed in the mould to be filled, as well as to smooth and consolidate the part choked. With the mould are used rammers, Fig. 36, formed of hard wood, of the shape of a popgun-stick; these rammers being rather less than the diameter of the cavity, and having a hole bored up their centre, in order to admit the piercer. It is evident that there must be a complete mould, piercer, and one or more rammers for every size rocket. But to proceed with the string; put it in the mould and the rammer down into it, and give the rammer a blow or two with a mallet, which driving it down while yet damp with the paste, will render the whole compact and smooth; and the case, being taken out, may be placed in an oven, or near the fire, to dry. If it is desired to ornament it in any way, or cover it with white paper, this must be done before choking.

Fig. 36.

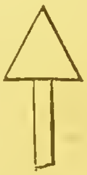


Charging.—The next process after drying the cases is to charge them with the requisite composition. Put the cases in the mould with the piercer in it, and put enough composition in to fill about 1 inch of the case; then, taking the rammer, ram it down with three or four strong blows with a mallet. Then put in the same quantity of composition again, and ram that down in the same manner, and so on till the case is filled to the top of the piercer and one diameter above it. Then separate some of the central folds of the paper which it has been observed is not parted, and turn them down upon the composition, ramming them down hard upon it, or, what will do as well, put in a piece of paper as wadding. When this is rammed down, and firm, bore with a brass bradawl three or four holes through it. These holes serve to make the requisite communication between two parts of the rocket. Or, having charged the case, take some common potter's clay in dry powder, and ram it down hard upon the top of the composition, then bore a hole through it about $\frac{3}{16}$ inch diameter, which will allow of the necessary connection between the rammed composition and the stars in the head or pot of the rocket.

Priming.—The rocket is now supposed to be closed at one end. It only requires to be primed at the other end, and that it will be observed is the end which was choked, which is still open, and which has a hole passing up it which the piercer occupied. To prime it, fill up the hole with loose gunpowder made into a stiff paste with very weak gum water, and paste a piece of touch-paper over it.

Pot or Head.—The rocket being then charged, the head or pot must be fixed. The pot is a paper case made upon a wooden former turned cylindrical, about 4 inches in length, and a shade larger in diameter than the exterior of the rocket case. Take some thick brown paper, and cut it in strips large enough to go twice round the former; paste and roll as for the case, then pinch one end, and a cylinder of paper will be thus made which should fit nicely over the clay end of the rocket. There should now be fixed upon the pinched end a conical cap, made upon a former of like shape, Fig. 37. This cap by cleaving the air assists the rocket in rising into it.

Fig. 37.



Loading.—The loading the pots with stars is all that now remains to be done to complete the rocket. A $\frac{1}{4}$-lb. rocket should carry about 1 oz. of stars. Weigh out the proper quantity of stars and mix them with meal powder, 6 parts to 1 part fine charcoal; fill up the pot, and glue it securely over the clay or upper end of the rocket case.

Sticks.—Next fasten the stick to the rocket by two strings, as seen in any of the figures 38 to 42, the sticks being previously prepared of proper length and size, as follows:—The smaller ones are easily and best made of those laths called by bricklayers double laths, and the larger ones pantile laths; but any slip of deal will answer the purpose. 2 lb. rockets require sticks 9 feet 4 inches long, 1 inch square at top, and rather more than ½ inch square at bottom. 1-lb. rocket sticks are 8 feet 2 inches long, ¾ inch square at top and ⅔ inch at bottom. 8-oz. rocket-sticks are 6 feet 2 inches long, ¾ inch square at top, and ⅔-inch at bottom. 4-oz. rocket sticks are 5 feet 3 inches long, ⅔ inch by ½ inch at top, and ¼ inch square at bottom. 2-oz. rocket sticks are 5 feet 1 inch long, $\frac{3}{10}$ inch by ½ inch at top, $\frac{4}{10}$ inch at bottom. 1-oz. rocket sticks are 3 feet 6 inches long, and so on for other various sizes. The weight and the length of the stick must be such, that when tied on, the rocket shall balance on the finger, at a point about 1 inch from the part choked.

Fig. 38.

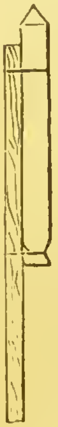


Fig. 39.

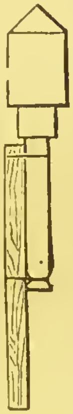


Fig. 40.

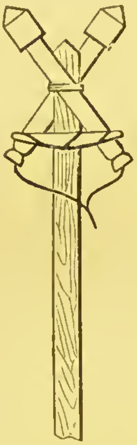


Fig. 41.

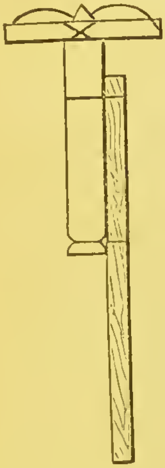
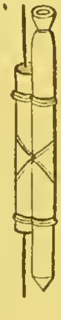


Fig. 42.



Compositions.—The brilliancy of the rocket depends upon the composition in the cases, and great care is required in the mixture of the ingredients, which should be well dried and carefully sifted through a hair sieve before mixing. For a ¼-lb. rocket, to 12 oz. of saltpetre add 6 of charcoal and 4 of sulphur; or for signal rockets the proportions are, saltpetre, 4 lb.; dogwood charcoal, 1 lb. 12 oz.; sublimed sulphur, 1 lb. Powder separately, and mix with the hand or a wooden spoon. Saltpetre increases the rapidity of the fire, whilst sulphur retards it, and the charcoal emits those volumes of sparks which form the golden train of an ascending rocket. Rockets are primed with mealed powder and spirits of wine.

Pyrotechnic and Rocket Stars.—The stars that are used as decorations to the different species of fireworks are of various kinds, sizes, and shapes, according to the purpose for which they are intended.

The ordinary rocket stars, which are called "brilliant" or "bright," are made in small cubes. Their composition is moistened with gum water, and while moist flattened to the thickness required. It is then scored or cut across with a knife, and allowed to dry. When dry, it can be easily broken up into cubes at the places where it was divided by the knife. Tailed stars are also made in the same way and of the same size.

Roman-candle stars are small cylinders of composition made of a size proportioned to that of the case out of which they are to be thrown.

Coloured rocket stars are made by driving the coloured composition, slightly moistened, into small cases, which go under the name of pill-box cases. If the star is to consist of one colour only, these pill-boxes are open at both ends, and a piece of quick-match is placed between the composition and the inside of the pill-box, and allowed to project about ½ inch beyond each end of it. When fired, these stars burn at both ends at the same time, and so produce a great amount of fire in proportion to their size.

If it is required to make stars consisting of more than one colour (in which case they are called "changeable stars") the pill-boxes are left open at one end only. The composition is thus prevented from burning at more than one of its surfaces at a time. These stars generally contain two colours; the pill-boxes are half filled with one coloured composition and the remaining space is filled with another. These changeable stars burn much longer than the others, and therefore produce a more beautiful effect; but being larger they require to be used in larger rockets, the ½ lb. size being the smallest that is adapted for this purpose.

There is another and exceedingly beautiful decoration for rocket-heads which is called golden rain. This is by no means a difficult thing to make. Some small paper cases are made about 2 inches long and of the size of goosequills; these are filled with a sparkling composition and primed with wetted gunpowder. They are placed, mouth downwards, in the head of the rocket, and arranged in such a manner that they may all be ignited. At the bursting of the rocket, they will describe a series of beautiful ringlets of sparkling fire.

Common Brilliant Stars.—Nitre, 16 parts; sulphur, 8; sulphide of antimony, 4; meal-powder, 3. Let all the ingredients be in as fine a powder as possible; and, having carefully weighed out the quantities, mix them thoroughly. Next, take some weak gum water made by dissolving 2 oz. of gum-arabic in a pint of warm water. Spread the star composition upon a piece of zinc plate or slate, and add to it a little of the gum water at a time, taking care to stir the composition about well till all the moisture is equally diffused. It is not necessary that this composition should be made wet, but only something like brown sugar in moistness, so that it will bind well when pressed together. When this is sufficiently done, roll or press the composition into a flat shape like a thick pancake, and make it as square as possible. Its thickness should be about ¼ inch. Take a blunt knife spatula, and with it score the composition across both ways, so that it is divided into a number of little cubes.

Tailed Stars.—These stars are not moistened with plain gum water, but with a mixture of gum water and linseed oil. The gum water should be of the strength given above, and should be made quite hot by placing the bottle which contains it in a jug of boiling water. When it is sufficiently hot, to every 8 oz. of gum water add 1 oz. of linseed oil. Shake the bottle till these are thoroughly mixed and no oil can be seen. Use the moistening fluid, while hot, in the same manner as directed above for brilliant stars. The following is the composition for tailed stars:—Nitre, 16 parts; meal-powder, 12; antimony sulphide, 8; fine charcoal, 4½; sulphur, 4.

Coloured Stars.—These require considerable care in their preparation, the beauty of their performance depending entirely upon the uniform fineness, the intimate union, and the dryness of their ingredients. The various preparations which enter into their composition should always be kept ready for use in fine dry powder, preserved in well-corked or stoppered bottles. The pill-boxes for coloured stars are made in the following manner:—Procure a piece of straight iron rod, 12 inches long, and ⅜ to ½ inch in size; the usual size for this former is about $\frac{7}{16}$ inch. Now cut some cartridge paper into strips about 8 inches wide, and 9 to 10 inches long; paste these strips all over, and roll them round the iron rod closely and neatly. When this is done, remove the case thus formed from the rod without tearing or breaking it, and set it aside to dry. When dry it will be very hard and stiff. It can then be cut, by means of a very sharp knife, into little lengths of ½ inch each. These lengths are the open pill-boxes, into which the composition is to be rammed for coloured rocket stars. In order to accomplish the filling of these cases with the least amount of trouble, procure a piece of stick, of a convenient length, and of such a size round that it will pass easily into the pill-boxes, and with a short groove cut in the side, sufficient to allow it to pass the quick-match without injuring it. Next take a small piece of quick-match, about 1½ inch long, and pass it through the pill-box in such a manner that it may project beyond each end about ½ inch. The composition pressed with the stick into these boxes is always slightly moistened; and by this means, when once dry, will not be liable to be shaken out again. The fluid employed for moistening these coloured compositions is a solution of shellac in methylated spirit of wine. Care must be taken not to make these compositions *wet*. A very slight moistening is sufficient to make them bind well when pressed into their cases.

Crimson Stars.—(*a*) Chlorate of potash, 24 parts; nitrate of strontia, 32; calomel, 12; sulphur, 6; shellac in fine powder, 6; sulphide of copper, 2; fine charcoal, 2.

(*b*) Chlorate of potash, 12 parts; nitrate of strontia, 20; sulphur, 11; charcoal, 2; antimony, 2; mastic, 1.

(*c*) Nitrate of strontia, 72; sulphur, 20; gunpowder, 6; coal-dust, 2.

Rose-coloured Stars.—Chlorate of potash, 20 parts; carbonate of strontia, 8; calomel, 10; shellac, 2; sulphur, 3; fine charcoal, 1. The advantage of this composition is that it is not at all liable to suffer from damp in winter. The carbonate of strontia is a salt not absorbent of moisture like the nitrate, and is, moreover, always to be had in a state of fine powder.

Green Stars.—(*a*) Chlorate of potash, 20 parts; nitrate of baryta, 40; calomel, 10; sulphur, 8; shellac, 3; fine charcoal, 1; fused sulphide of copper, 1.

(*b*) Nitrate of baryta, 42 parts; realgar, 2; sulphur, 8; lampblack, 1.

(*c*) Chlorate of potash, 28 parts; nitrate of baryta, 12; sulphur, 15; mastic, 1.

Pale Rose-coloured Stars.—Nitrate of strontia, 8 parts; chlorate of potash, 4; sulpher, 3; sulphide of antimony, 2. Take especial care that the nitrate of strontia used in this formula is very dry.

Pale Green Stars.—Nitrate of baryta, 16 parts; chlorate of potash, 8; sulphur, 6; antimony, 3.

Yellow Stars.—(*a*) Chlorate of potash, 20 parts; bicarbonate of soda, 10; sulphur, 5; mastic, 1.

(*b*) Chlorate of potash, 30; dried soda, 12; sulphur, 8.

Golden Yellow Stars.—Chlorate of potash, 20 parts; nitrate of baryta, 30; oxalate of soda, 15; sulphur, 8; shellac, 4. If it is thought advisable to give the stars made from this formula a tailed appearance, add one part of fine charcoal. The composition is to be moistened with the shellac solution. The stars form a beautiful contrast with those of an intense blue.

Blue Stars.—(*a*) Chlorate of potash, 8 parts; sulphide of copper, 6; Chertier's copper, 5; sulphur, 4.

(*b*) Chlorate of potash, 12 parts; Chertier's copper, 6; sulphur, 4; calomel, 1.

(*c*) Chlorate of potash, 16 parts; Chertier's copper, 12; calomel, 8; stearine, 2; sulphur, 2; shellac, 1. This gives a most intense blue.

(*d*) Chlorate of potash, 20 parts; carbonate of copper, 14; sulphur, 12; mastic, 1.

(*e*) Nitre, 12 parts; sulphide of antimony, 2; sulphur, 4; lampblack, 2. All these compositions should be moistened with gum water, and in No. 3 the stearine employed must be in fine powder.

Violet Stars.—Chlorate of potash, 9 parts; nitrate of strontia, 4; sulphur, 6; carbonate of copper, 1: calomel, 1; mastic, 1

White Stars.—Saltpetre, 9 parts; sulphur, 3; antimony, 2.

To prepare Chertier's Copper.—Take any quantity of common sulphate of copper, or blue vitriol, and dissolve it in as little water as possible; then take an equal quantity by weight of chlorate of potash and also dissolve it in as little water as will hold it in solution. Mix these two solutions, and boil them gently over a clear fire until the moisture is nearly evaporated; then dry the green precipitate that remains by a gentle heat. When dry, treat it with strong liquor ammoniæ till it changes to a deep blue colour; then let it dry very gradually in a warm place. If this operation be properly performed you have a fine, very light blue powder, which is Chertier's copper.

To prepare Nitrate of Strontia.—Procure a common earthenware pipkin, or a glazed iron frying-pan of a convenient size. Into this place nitrate of strontia in rough crystals; 1 or 2 lb. will be sufficient to prepare at a time. Place the vessel on a clear fire, but do not make it too hot. Now boil, or rather stew, the crystals in their own water of crystallisation. The heat will soon cause them to run into a thick pulpy mass. When in this state, they must be constantly stirred, or upon the evaporation of the moisture they will resume a crystalline form. Continue then to stir it with a stick or flat piece of wood until the moisture is driven off by the heat, and the salt remains in the condition of a white dry sand. No unprepared strontia can be used for coloured stars or fires, and this operation is proper also for the preparation of the nitrate of baryta.

GOLDEN RAIN. — Golden rains are made in the following manner:—Procure a piece of brass rod, the diameter of which is $\frac{3}{16}$ inch, or rather less. The length of the former may be 6 to 8 inches. Cut thin brown paper into short strips, about 2 inches wide, and long enough, when wrapped round the former, to make a case whose external diameter shall be $\frac{1}{4}$ inch, or, rather more. The former should have a small cup-shaped hollow cut in one of its ends, into which the paper may be turned, to form a closed end to the cases. Paste the strips of paper all over, and also rub some paste on the former; then roll the paper round the former, and draw it out so as to leave its cupped end $\frac{1}{4}$ inch inside one of the ends of the case. Pinch in the paper that projects beyond the former, and drive it down with a tap upon the pasting slab, so that the twisted end is pressed into the cup of the former. By this means a neat and secure end is obtained for the cases, which may be dipped afterwards into warm size or glue. If a little red-lead is mixed with this size, it will solidify much more rapidly. This dipping the ends of the cases into size should not be done until they are dry from the paste. For filling the cases a tin funnel is used that will exactly fit into the mouth of golden-rain cases.

The compositions employed for filling the cases are the following:—(*a*) Meal-powder, 6 pts.; nitre, 1; fine charcoal, 2.

(*b*) Meal-powder, 8 parts; fine charcoal, 3.

(*c*) Saltpetre, 1 lb.; meal-powder, 4 oz.; sulphur, 4 oz.; brass dust, 1 oz.; sawdust, $2\frac{1}{4}$ oz.; glass dust, 6 dr.

When the case is charged, the funnel must be removed, and the space that was occupied by its nozzle filled with gunpowder or meal-powder, moistened with gum water. This will prevent the composition from being shaken out of the cases, and at the same time forms the best method of priming them. Take care that this paste is pressed well into the mouth of the cases, and fills them.

Silver Rain. — (*a*) Saltpetre, 4 oz.; sulphur, mealed powder, and antimony, each 2 oz.; sal prunella, $\frac{1}{2}$ oz.

(*b*) Saltpetre, 8 oz.; sulphur, 2 oz.; charcoal, 4 oz.

(*c*) Saltpetre, 1 lb.; antimony, 6 oz.; sulphur, 4 oz.

(*d*) Saltpetre, 4 oz.; sulphur, 1 oz.; powder, 2 oz.; steel dust, $\frac{3}{4}$ oz.

Used in similar cases and treated in the same way as *golden rain.*

PORTFIRES.—The portfires used for firing rockets and fireworks are generally made in the following manner:—

The former for this purpose should be of brass, and not less than ¼ inch in diameter, and the wire for filling them not less than ⅛ inch. Portfire cases are usually made very thin, but prepared in precisely the same manner as golden rains, and are also primed in the same way. The following are the compositions usually employed for portfires.

(*a*) Nitre, 6 parts; sulphur, 2; meal-powder, 1.

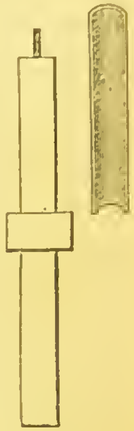
(*b*) Saltpetre, 2 lb.; sulphur, 3 lb.; antimony, 1 lb.

(*c*) Saltpetre, 3½ lb.; sulphur, 2½ lb.; meal-powder, 1 lb.; antimony, ½ lb.; glass dust, 4 oz.; brass dust, 1 oz.

ROMAN CANDLES.—In the manufacture of these fireworks, the following important points must be observed, namely, to have a composition to burn in the intervals between the stars, which will throw a jet of fire uniformly good throughout; to have stars of tolerably rapid combustion, otherwise they will not be ignited before they are blown into the air; and to have the charges of powder for blowing the stars regulated to a great nicety. The former for the cases must be ⅝ inch in diameter, and 18 inches long. The cases require rather a large amount of paper and imperial board for their manufacture, but otherwise they are made similar to rocket cases.

Roman-candle Stars.—The brilliant stars may be made of the same composition as that given for rocket stars of that kind. If, however, a whiter star is required, use the following:—Nitre, 48 parts; sulphur, 10; regulus of antimony, 8; realgar, 6; red-lead, 4; shellac, 1. Yellow Roman-candle stars may be made from the same formula as that given for yellow rocket stars. Green Roman-candle stars may be made from the formulas given for rocket stars; but there is also another formula, which produces a rather deeper tint, but is hardly rapid enough in combustion for rocket stars. It is the following:—Nitrate of baryta, 40 parts; chlorate of potash, 20; calomel, 12; sulphur, 12; fine shellac, 4; fine charcoal, 1. The formulas for crimson, rose, blue, and purple Roman-candle stars are the same as given for rocket stars. In order to make the stars, moisten the compositions very slightly. The mould in which these stars are shaped is a brass tube, Fig 43, of a size proportioned to the size of the Roman-candle case, and is generally about $\frac{1}{16}$ inch smaller in its inner diameter than the case. The drift with which the composition is pressed into the tube, is made of box-wood or metal, and fits easily into the tubular mould. At one of its ends is a wire point. Place the end having the point in the mould as far as it will go. It will leave a space at the end of the mould unoccupied by the drift. Press this empty end of the tube into the slightly-moistened composition until it is filled by it, so that the drift, being driven down upon the composition, will compress it into a firm cylindrical mass, into the centre of which the wire point projects. When the star is thus formed in the mould, the drift must be withdrawn, reversed, its long plain end inserted, and the star pushed out. The object of making the star hollow is that it may dry and harden perfectly in its centre, and also for the priming of the star, which is effected by placing a little piece of quick-match into the hole in the star, and allowing it to project about ¼ inch above. By this means even slowly-combustible stars are ignited, and almost every chance of failure is avoided. This priming, however, should not be done until the stars are to be put into the cases—at all events not till they are perfectly dry.

Fig. 43.



Composition for Roman Candles.—(*a*) Nitre, 18 parts; sulphur, 6; fine charcoal, 7; meal-powder, 4.

(*b*) Nitre, 16 parts; meal-powder, 8; fine charcoal, 6; sulphur, 6.

(*c*) Nitre, 16 parts; meal-powder, 11; sulphur, 6; antimony, 4.

The next thing is to fill the case. Before filling it, introduce a little clay to the bottom of the case, thus forming a better and firmer bottom. This being done properly, put in a little coarse powder, and over this a small piece of paper, to prevent the composition mixing with the powder; then ram down as much composition as will fill the case one-sixth of its height; over this put a small piece of paper covering about two-thirds of the diameter, then a little corn powder, and upon that a ball, observing that the ball is rather smaller than the diameter of the case. Over this first ball more of the composition must be put and rammed lightly down to prevent breaking the ball, till the case is one-third full; then a piece of paper, a little powder, and then another ball as before, till the case is filled with balls and composition, taking care to place composition above the highest ball. When the case is thus filled, cap it with touchpaper by pasting it round the orifice, and a little priming of powder being added the work is complete.

TOUCHPAPER. — Obtain some thin blue paper—not so thin as tissue paper, but thinner than the ordinary blue paper used by storekeepers; brush or sponge this over with or dip it into a weak solution of saltpetre, and when well saturated dry for use. Touchpaper should be cut into slips, placed once round the mouth of the firework, and twisted into a point.

QUICK-MATCH.—Make a thick paste of gunpowder and hot water, with a small quantity of gum in it. Take about four strands of cotton, such as is sold in balls, and used for making the wicks of lamps, steep this in the solution of nitre used for making touchpaper, and wring it as dry as possible; then rub it well in the gunpowder paste till it is thoroughly covered with it. One end of the cotton may be passed through a small funnel, whose mouth is not more than $\frac{1}{8}$ inch in width. By this means, if the whole length of the cotton is drawn through it, the superfluous paste will be removed, and the match will be of a nice round form. Hang it out of doors on a dry day, and when it is nearly dry coil it upon a tray or paper, and dust it over with meal-powder. In winter it will not be sufficiently dry for use under a week. When thoroughly dry it should be stiff and hard, and the less it is bent or doubled the better. To use this match for connecting the mouths of different fireworks, or "clothing" them as it is termed, make some long paper tubes round a wire former which has a diameter of not less than $\frac{3}{16}$ inch. These pipes are threaded on the match, and have a piece cut away at their side wherever they are inserted into the mouth of a case, in order that the match may be laid bare and convey its fire to the priming of the cases.

GERBES AND JETS OF BRILLIANT, CHINESE, AND COMMON FIRES.—These are certainly among the most beautiful and effective pieces to be met with in the whole range of pyrotechny. They have one great advantage—that there is no limit to the modes of combination or arrangement in which these pieces may be effectively employed. By means of them any such things as the following can be made :—Fountains of any size or design, cascades, brilliant suns, either fixed or revolving, bouquets of Chinese fire, spread eagle, trees of silver flowers, and a thousand other devices. Their compositions, to produce the desired effect, must be made as shortly as possible before it is intended to fire them, as iron and steel filings are a principal ingredient in their composition. Many attempts have been made to secure these metallic ingredients from corrosion. A coating of any kind is tolerably certain either to rob the spark which each particle of metal should produce of its brilliancy, or to render the composition during combustion very smoky, and so impair the intended effect. The most successful plan is the following :—A weak solution of asphalt in naphtha is made, and the filings or borings are stirred about in this. When it is thought that they are thoroughly covered with it, the solution is poured off, and the filings are spread out upon paper to dry. But still the best way is to prepare the compositions as short a time as possible before they are to be fired. The cases should be made like rocket cases, and choked while wet, only it must be remembered that their aperture may be almost choked up, because when it has been reopened by the point over which they are loaded, it must not be more than $\frac{1}{3}$ of the interior diameter of the case in size.

Red Chinese Fire.—(*a*) Meal-powder, 16 parts; nitre, 16; sulphur, 4; charcoal, 4; iron borings, 14.

(*b*) Meal-powder, 16 parts; sulphur, 3; charcoal, 3; iron borings, 7.

(*c*) Meal-powder, 8 parts; nitre, 16; sulphur, 3; charcoal, 3; iron borings, 8.

(*d*) Meal-powder, 16 parts; nitre, 8; sulphur, 4; charcoal, 3; iron borings, 7.

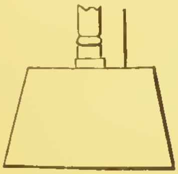
White Chinese Fire.—(*a*) Meal-powder, 16 parts; nitre, 6; sulphur, 3; iron borings, 10.

(*b*) Meal-powder, 16 parts; nitre, 4; sulphur, 2; iron borings, 6.

(*c*) Meal-powder, 16 parts; iron borings, 5.

For filling the cases, nipples of various sizes are employed, made preferably of metal. The case must now be pressed over the point of the nipple, Fig. 44, and by this means its aperture will be made of the proper size. It will be found very convenient to have a ring of iron fixed into your block, through which the case must be passed, which will steady it and keep it in a perpendicular position while being filled. Now drive in the composition, a ladleful at a time, and after putting in each ladleful, give the drift twelve blows with the mallet. Fill the cases till there remains a space of 2 inches only unoccupied at the end. Into this end put a gun charge and a half of gunpowder. Then with a bradawl separate one or two of the inner folds of the paper of the case, and turn these down on the top of the powder.

Fig. 44.



For filling in the ends of the cases:—Melt in an earthen pipkin a mixture of 2 parts of common rosin and 1 of wax. This may be poured into the ends of the cases upon the paper that has been turned down. It will harden in a few minutes, and will be found to ensure a good report from the powder. To prime these cases is an operation requiring some care, although it may be performed in a very simple manner. If the point of the nipple is not too long, all that is needed is to press into the mouth of the case some meal-powder paste; but if a cavity has been left in the composition, this must be filled up before priming, or the case will inevitably burst. It is an excellent plan to take for the first ladleful, not any of the compositions for Chinese fire, but a ladleful of some slower fire containing no iron borings, such as a mixture consisting of nitre, 6 parts; sulphur, 1; charcoal, 1. These gerbes or jets are exhibited, when finished, by being attached to strong frames of wood or metal, arranged in such a manner as the exhibitor may wish, to produce any desired effect. The mouths of the cases are connected by means of leaders or quick-match.

Brilliant Fire.—The cases employed for brilliant fire need not be so large as those employed for Chinese fire, but observe the same rules in filling these cases.

(*a*) Meal-powder, 4 parts; bright steel filings, 1.

(*b*) Meal-powder, 16 parts; nitre, 8; sulphur, 3; fine charcoal, 3; bright steel filings, 10. Neither of these compositions should on any account be mixed before their preparation is absolutely necessary, for their whole beauty depends upon the brightness of the filings at the time of firing.

Common and Sparkling Fires.—(*a*) Meal-powder, 4 parts; charcoal, 1.

(*b*) Meal-powder, 16 parts; nitre, 8; sulphur, 4; charcoal, 4.

(*c*) Meal-powder, 16 parts; very fine glass dust, 5.

(*d*) Meal-powder, 8 parts; very finely powdered porcelain, 3.

These fires can be arranged very effectively as stars, suns, &c. For instance, provide a circular disk of hard wood, 6 inches in diameter, and 1 inch thick. Nail to this five spokes of wood at equal distances from one another, and 15 inches long. Nail also to the back of the central disk a strip of wood about 2 feet long, 2 inches wide, and $\frac{3}{4}$ inch thick. By means of this you can screw the whole piece conveniently to your firing post. On each of the five spokes tie a case of brilliant fire, reported at its end, and connect the mouths of these with quick-match.

Lances.—Lances are used in making up devices, such as names, mottoes, wreaths, and so on. They consist of small cases, generally made about $\frac{3}{16}$ inch in diameter, that is, round a piece of glass or brass rod or tube of that size; tubes are always best for these small formers. The cases are about 2 or 2½ inches long, with one end pinched or turned in. Two rounds of thin demy or double-crown white paper, pasted, will give sufficient thickness and substance for the case. The cases, when dry, are to be filled with either of the following compositions in the same way as golden rain:—

Compositions for Lances. White.—(*a*) Nitre, 16 parts; sulphur, 8; meal-powder, 6.

(*b*) Nitre, 16 parts; sulphur, 4; meal-powder, 6.

(*c*) Nitre, 12 parts; sulphur, 4; sulphide of antimony, 3.

(*d*) Nitre, 72 parts; sulphur, 18; regulus of antimony, 33; realgar, 1; shellac, 1.

(*e*) Nitre, 96 parts; sulphur, 24; regulus of antimony, 48; realgar, 6; shellac, 1.

These for the most part give a bluish white flame, and when employed in cases of the size mentioned above, burn slowly, and will last as long as this species of firework is required to last.

Yellow.—(*a*) Chlorate of potash, 72 parts; oxalate of soda, 60; stearine, 6; sulphur, 6.

(*b*) Chlorate of potash, 40 parts; oxalate of soda, 16; shellac, 8; stearine, 3.

Green.—(*a*) Chlorate of potash, 60 parts; nitrate of baryta, 41; calomel, 49; powdered sugar, 30; shellac, 1.

(*b*) Chlorate of potash, 63 parts; nitrate of baryta, 50; calomel, 50; sugar, 32; shellac, 1.

(*c*) Chlorate of baryta, 18 parts; calomel, 7; very fine shellac, 3.

(*d*) Chlorate of baryta, 24 parts; stearine, 3; very fine sugar, 1.

Red.—(*a*) Chlorate of potash, 13 parts; nitrate of strontia, 10; calomel, 8; shellac, 3; dextrine, 1; Chertier's copper, 1; fine charcoal, 1.

Rose-coloured.—Chlorate of potash, 24 parts; sulphur, 2; stearine, 3; oxalate of strontia, 4. This composition will remain good for any length of time.

Blue.—(*a*) Chlorate of potash, 12 parts; Chertier's copper, 6; sulphur, 4; calomel, 1.

(*b*) Chlorate of potash, 32 parts; Chertier's copper, 12; calomel, 40; sugar, 25.

(*c*) Chlorate of potash, 6 parts; Chertier's copper, 1; calomel, 5; sugar, 4.

Violet.—Chlorate of potash, 26 parts; calomel, 24; carbonate of strontia, 4; Chertier's copper, 3; sugar, 14.

Lilac.—Chlorate of potash, 12 parts; prepared chalk, 4; sulphur, 5; calomel, 3; sulphide of copper, 10. Sugar for pyrotechnic compositions must be kept in a closely-corked or stoppered bottle. It should be reduced to powder in a very dry mortar, and then sifted through very fine muslin.

To exhibit lances, procure a board of sufficient size for the design, or make a wooden framework of the shape that is required. Sketch the design upon one side of the board, or, if larger than board will allow, make a plain rough framework describing the letters. When this is done, decide upon the distance at which to place the lances one from another. This distance is generally about 2 inches, but no exact rule can be laid down, for much depends upon the kind of design, and upon its size. On the outlines of the sketch make little pencil circles wherever it is intended to place a lance; and, as far as it is possible, arrange that the lances shall be equidistant one from another. Now with a centre-bit, or, what is better, a pin-bit, bore a hole about $\frac{1}{4}$ inch deep where the circles are pencilled. These holes must be of such a size that the closed ends of the lances will fit easily into them. Get either some glue or some of the mixture of size and red-lead, and when it is liquid, dip into it the closed end of each of the lances. Enough of the mixture will adhere to the lances to allow of their being secured firmly in the holes that have been bored. In a very short time all will be hard and dry, and you will then have a series of lances projecting at right angles with your board or framework, each having its mouth primed, and all being the same length. The only thing that remains now to be done is to clothe these primed mouths with quick-match. This is by no means difficult, but requires a certain amount of patience. Take a length of match in its case, and, having exposed one end of the black match itself, put a small pin through it into the priming of one of the lances. This will fasten it down, and at the same time will ensure ignition. Then lead the quick-match on to the next lance, cutting away with scissors a piece of the under side of its case, to allow the match in passing to touch its priming. Put a pin through the match into the priming of this lance also, and so on till all are clothed. If more of the casing of the match has been cut away than is necessary, it will be well to paste small strips of paper wherever this has happened, as any exposure of the black match will endanger the piece, rendering it liable to ignition from the sparks of other fireworks.

COLOURED LIGHTS.—Their preparation is exceedingly simple. They are generally made in two sizes only; these are the 2-oz. and the 1-oz. sizes. The cases are made of cartridge or foolscap paper, and are about 2 inches long for the 2-oz. size and 1¾ inch for the 1-oz. size. Used-up copy-books furnish excellent paper for making these coloured-light cases. Three or four rounds o the paper will give ample thickness for the case. The paper should be pasted all the way along the strips. When the cases are thoroughly dry, ram into the bottom of them some dry powdered clay; this will make a close end, and will also furnish an incombustible part by which the case may be tied or fastened to its place.

White, for Decoration.—(*a*) Nitre, 4 parts; sulphur, 1; sulphide of antimony, 1.

(*b*) Nitre, 4 parts; sulphur, 1; meal-powder, 1.

These will give the ordinary bluish light, and compositions made from them will remain good for any length of time.

Yellow may be made from the formulas given under the head of Lances.

Green.—Nitrate of baryta, 80 parts; chlorate of potash, 32; sulphur, 24; calomel, 16; fine charcoal, 3; shellac, 2.

Red.—(*a*) Chlorate of potash, 32 parts; nitrate of strontia, 48; calomel, 20; shellac, 1½; Chertier's copper, 4; fine charcoal, 1.

(*b*) Chlorate of potash, 84 parts; nitrate of strontia, 80; calomel, 51; dextrine, 22; shellac, 18; Chertier's copper, 4.

Purple.—(*a*) Chlorate of potash, 28 parts; Chertier's copper, 28; calomel, 13; shellac, 8; stearine, 1.

(*b*) Chlorate of potash, 40 parts; calomel, 28; Chertier's copper, 28; dextrine, 10; stearine, 3.

(*c*) Chlorate of potash, 26 parts; Chertier's copper, 24; calomel, 14; shellac, 7.

TOURBILLIONS.—The tourbillion is a species of firework very ingeniously contrived to represent a spiral column of fire. Its performance is of short duration, but while it lasts it produces a very striking effect. A tourbillon consists of a stout case filled with a strong sparkling composition, and closed very tightly at both ends. In this case are bored four holes, at which the fire is to find vent. Two of these holes are made underneath the case; from these the fire issues in a downward direction, and gives the piece the power of ascending perpendicularly. The outer two holes are made in opposite sides of the case near each end; the fire issuing from these causes the case to revolve in a horizontal direction while it is ascending. The cases are made as for rockets, and should be about 8 inches in length, and $\frac{3}{4}$ inch in their bore. Their external diameter will be found to be about $1\frac{1}{8}$ inch.

Plain.—Nitre, 8 parts; meal-powder, 16; sulphur, 4; charcoal, 4.

Brilliant.—Meal-powder, 16 parts; nitre, 8; sulphur, 3 to 4; fine charcoal, 3; steel filings 6. Tourbillion cases are filled by means of an apparatus which consists of a block of wood, Figs. 45, 46, provided with a settle *n*, on which one end of the tourbillion case is placed, and over which the composition is rammed. There is a wooden mould for enclosing the case and supporting it tightly and firmly while the operation of ramming is being performed. This mould Q, Fig. 46, consists of a hollow cylinder of wood pierced throughout, and of such a size in its bore as will just admit the tourbillion case. The mould is divided longitudially in halves, and these halves are kept together by means of iron rings O, which encircle the whole. P is a pin to pass through cylinder and settle to connect them. In order to fill the cases, squeeze one end of one of them over the projecting piece at the top of the settle. Fit on the two halves of the cylindrical mould, drive down the iron rings until they are tight, and put in the pin which secures the cylinder to the block and settle. First put into the tourbillion case as much clay as will, when rammed very hard, occupy $\frac{3}{8}$ inch in the length of the case. The settle projects into the case about $\frac{1}{8}$ inch, and thus $\frac{1}{2}$ inch at each end of the case is left for the purpose of ensuring a very firm ending, which cannot be blown out by the combustion of the composition. When the clay has been rammed in as tightly as possible, drive in the composition, a ladleful at a time, as uniformly as possible, until only $\frac{1}{2}$ inch at the upper end of the case is unoccupied by it. Into this vacant space drive the same quantity of clay that was put into the lower end, and be sure that it is rammed in very firmly. When this is done, open your penknife, and lay its blade on the table, back downwards and edge upwards. Place the filled tourbillion case across the edge of the knife, and find the exact central point at which it balances on it, and mark that point by making a hole there with a small bradawl. Now, having found the centre of its balance, next mark the places at which the holes are to be made, and by far the best way is to use a shape made of zinc or tin, such as is shown Fig. 47.

Fig. 45.

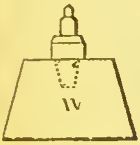


Fig. 46.

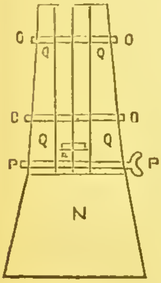
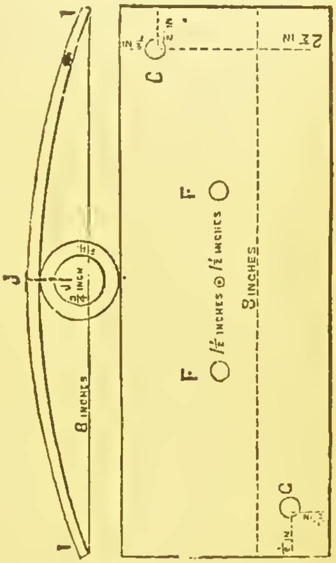
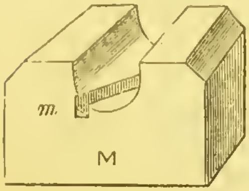


Fig. 47.



This piece of sheet metal, when bent into the form of a trough of such a size as to fit tightly round the tourbillion case, will give the true position of the holes. In using it put the filled tourbillion case into it, and make pencil marks through the holes that correspond to those drawn in the Fig. 47, and you will then have got over the entire difficulty. In the middle of the scale is one small hole. This hole is to come exactly over the mark made with the bradawl at the balancing point, and if this be done all the rest must come right. Having

Fig. 48.



thus marked the position of the holes, the next thing is to bore them. This is best effected by means of a bradawl driven by a mallet, the tourbillion during the operation being laid upon a small block of wood M, with a groove cut in it as *m*, Fig. 48. The holes should be as nearly as possible $\frac{3}{16}$ inch in size. It is easier to drive the bradawl with a mallet than to work it in with the hand. It must not be driven in farther than necessary, the object being merely to make a clear hole through. If a block is 2 inches square or rather more it will be quite large enough. The block will be found very useful afterwards. The two extreme holes, which are on opposite sides of the case, are made at the ends of the composition; the fire issuing from these gives the tourbillion a horizontal revolution round its centre of balance. The two inner holes, which are on the under side of the case, should be the same distance from one another that they are from the extreme holes; the fire issuing from these gives the tourbillion its ascending power. We have now to connect all these holes with quick-match, in order that the composition may take fire at all the four points simultaneously; and unless this is attended to with care, it will not only cause the tourbillion to fire irregularly, but entirely destroy its effect. Begin at one of the under holes, those marked F in Fig. 47, and press into it the end of a piece of uncased quick-match, taking care that the match reaches the composition. Then carry the match on to the nearest side hole, and press it into it. Carry on the quick-match over the upper side of the tourbillion to the side hole at the other end of the case, and press it in there; and, lastly, carry it on to the remaining under hole, and press it into it. Having completed this operation, cut some strips of thin paper, about 1 in. wide, paste them well over, and cover the quick-match with them, holes and all. A very little practice will enable one to adapt this pasted paper very neatly. The tourbillion, if now ignited, will be sure to go somewhere, but in order to regulate its flight we must adjust a stick to it, which shall have the effect of keeping its under side downwards, and so of compelling it to move upwards perpendicularly. This stick is usually made of beech, 8 inches long, about $\frac{1}{8}$ inch thick, and of a curved shape, in the manner represented at I in Fig. 47. There is a small hole in the centre through which a flat-headed nail is driven into the tourbillion at its balance point. The stick must, of course, lie at right angles with the case in the manner represented at R, Fig. 49.

Fig. 49.

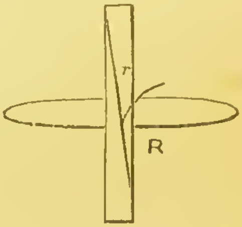
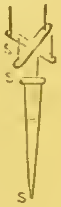


Fig. 50.



It is a very good plan to put a drop or two of glue at the point where the stick touches the case, as it will then be prevented from shifting its position. In driving the nail through the stick into the tourbillion, make use of the block represented at M, having previously cut at the bottom of its rounded groove another small groove diagonally, so that when the tourbillion is lying upside down in the large groove, for the purpose of having the nail driven into it, the quick-match that extends across it may lie in the smaller groove, and may not be injured by being crushed, as would otherwise be the case. The nails used should be about $\frac{3}{4}$ inch long, and should have a smooth, flat head. To fire the tourbillion, place it stick downwards on a level board, and see that it spins easily and freely on the head of the nail. Then with a portfire burn through the quick-match in the middle on the upper side. The tourbillion will make a few revolutions on the board before it begins to rise.

Reference to Figs. 46 *to* 50.—M, block to receive the tourbillion while it is being bored. *m*, groove in it to receive the quick-match. N, block, with settle (*n*) over which tourbillions are rammed. Q, wooden cylinder to enclose tourbillon case. O, iron rings to tighten cylinder. P, pin to pass through cylinder and settle to connect them. R, tourbillion complete, with stick attached. S (Fig. 50), revolving cradle from which tourbillions are fired, and iron spike, with tubular top, in which the cradle revolves.

DRAWING-ROOM FIREWORKS.—*Lightning Paper.*—Dry 1000 gr. pure nitre at a moderate heat, place it in a dry retort, pour on it 10 dr. by measure of strong sulphuric acid, and distil until 6 dr. nitric acid have passed over into the receiver. Dry some thin unsized paper, such as filter paper, and weigh out 60 gr. of it. Mix 5 measured drachms of the nitric acid with an equal volume of strong sulphuric acid in a small glass vessel; allow the mixture to cool; immerse the paper, pressing it down with a glass rod, cover the vessel with a glass plate, and set it aside for 15 or 20 minutes. Lift the paper out with a glass rod, throw it into a bucket of water, and wash it thoroughly in a stream of water till it no longer tastes acid or reddens blue litmus paper. Dry it by exposure to the air, or at a very gentle heat.

Japanese Matches.—Lampblack, 5; sulphur, 11; gunpowder from 26 to 30 parts, this last proportion varying with the quality of the powder. Grind very fine, and make the material into a paste with alcohol; form it into dice about $\frac{1}{4}$ inch square, with a knife or spatula; let them dry rather gradually on a warm mantelpiece, not too near a fire. When dry, fix one of the little squares into a small cleft made at the end of a lavender stalk, or, what is better, the solid straw-like material of which housemaids' carpet-brooms are made. Light the material at a candle, hold the stem downward. After the first blazing off, a ball of molten lava will form, from which the curious coruscations will soon appear.

QUICK-MATCH.—Quick-match is made of cotton lamp-wick thread, soaked for an hour or two in a mixture of gunpowder, $1\frac{1}{2}$ lb., and gum water, made by dissolving 2 oz. of gum-arabic in 1 pint of water, into which the gunpowder should be beaten up till dissolved. The cotton may be 3, 4, or more strands in thickness, and should be wound off out of the mixture, passed through a funnel pipe to make it even, and dried on a frame. It must be enclosed in paper tubes for use, as it will not burn with the necessary rapidity if not covered.

Another method is by coating lamp-cotton as thickly as possible with meal-powder, rendered adhesive by mixture of thick gum-arabic, and covered by two strips of paper wound round it spirally, one over the other in opposite directions, the outer one being pasted to the inner. See also p. 87.

FIRE BALLOONS.—The material for making a small balloon should be a fine, thin, close-textured tissue paper. Having determined that the balloon shall consist of a specific number of gores, or sections, say 34 or 16, a pattern for cutting them by should be made of pasteboard, or some tolerably hard substance. Suppose the entire height of the balloon, without its appendages, is to be 3 feet, and the number of gores 32, an elegant shape will be got by making the pattern 1 inch wide at one end, 3 inches at the other, and 8 inches at its broadest part, which should be at one-third of its length, if the balloon is intended to have a pear-like figure. Varnish the gores with the ordinary boiled oil, and hang them up singly on lines till perfectly dry. They are next to be put together, which may be done with gum water or clean thin paste. After pasting or gumming about $\frac{1}{2}$ inch of one of the gores, lay the edge of another about midway across the part pasted, and then double over about $\frac{1}{4}$ inch of it, dabbing it lightly from end to end with a clean cloth, to ensure its holding securely. Two of the gores being thus united, unite two others in like manner, and so on, until, if there were 32 gores in all, the number is reduced to 16. In like manner proceed till the number is eight, then four, and then two; hanging the sections up at every pasting, so that they may get thoroughly dry whilst proceeding. The two halves are last of all to be connected in the same way; and this part of the undertaking is then completed. A circle of wire, about 6 inches in diameter, should be worked into the bottom of it, to keep the fabric of the balloon at a sufficient distance from the flame of the spirit. Another wire may be fixed across this circle to hold a piece of sponge, which should be immersed in spirits of wine. A smouldering piece of brown paper held underneath the aperture will in a few minutes put the balloon in an ascending condition. Having thus inflated the balloon, ignite the piece of sponge, and let it rise. When it is intended to inflate the balloon with hydrogen or coal gas, the latter apparatus is not needed; but a light car, or any other ornament proportioned to the ascending power of the balloon, may be appended to it, which will have the effect of maintaining it in the right position, and also of keeping it longer in sight than would otherwise be the case.

SALTPETRE FROM DAMAGED GUNPOWDER.—Dissolve the powder in warm water, filter the solution through fine linen bags, and then evaporate the water by boiling it, until the solution is of sufficient strength to crystallise.

SERPENTS, OR SQUIBS.—(*a*) Mealed powder, 1½ lb.; charcoal, 4 oz.; sulphur, 1 oz.; saltpetre, 3 oz.

(*b*) Mealed powder, 1 lb.; charcoal, 1 oz.; saltpetre, 1¾ oz.; steel filings, 1 oz.

The case is made by rolling cartridge paper in slips of 6 or 8 inches in breadth round a former, and pasting down the last fold, for serpents. The case, having been choked at one end, is filled by inserting a funnel into the case, filling the funnel with composition, and gently moving a rod or rammer up and down the funnel-pipe, the rod being introduced before the composition. A piece of touchpaper is fastened to the end. For squibs, before filling the case, ram in hard a thimbleful of coarse gunpowder.

SHOWERS OF FIRE. – *Chinese Fire.*—Mealed powder, 1 lb.; sulphur, 2 oz.; iron filings, 5 oz.

Ancient Fire.—Mealed powder, 1 lb.; charcoal, 2 oz. To form a shower of fire, mould small paper cases on a rod, $\frac{2}{10}$ inch in diameter, and 2½ inches in length. They must not be choked, as it will be sufficient to twist the end of the case, and having put the rod into it, beat it to make it assume its form. When the cases are filled, which is done by immersing them in the composition, fold down the other end, and then apply a match. They must be fixed on a frame with leaders, to be fired simultaneously.

PIN, OR CATHERINE, WHEELS.—Mealed powder, 12 oz.; saltpetre, 3 oz.; sulphur, 1½ oz. The pipe or case is made on a long wire former, about $\frac{3}{16}$ inch in diameter, into which the composition is poured through a funnel, and shaken down. The case is then rolled round a small circle of wood about 1 inch in diameter, and not more than ½ inch thick, with a hole through the centre of it, for a nail, or pin. One end of the case is to be pasted round the wood, and each half turn of it secured with sealing wax, or a strip of paper pasted across the wheel. The end is then primed.

CRACKERS.—The case is made of cartridge paper, the dimensions required being 15 inches by 3½ inches. First fold down one edge, about ¾ inch broad, then turn down the double edge about ¼ inch, and bend back the single edge over the double fold, so as to form within a channel, which is to be filled with mealed powder, not ground very fine; the powder is then covered by the folds on each side, and the whole is pressed by a flat ruler. The part containing the powder is folded into the remainder of the paper, every fold being pressed down. The cracker is then doubled backwards and forwards in folds about 2¼ inches, which are pressed quite close.

A piece of twine is passed twice round the middle across the folds, and the joinings are secured by causing the twine to take a turn round the middle at each fold successively; one of the ends of the folds may be doubled short under, which will produce an extra report; the other must project a little beyond the rest for the purpose of being primed.

COLOURED FIRES.—In the preparation of coloured fires the utmost care should be taken to have the component parts of the mixtures well triturated apart from each other, passed through fine sieves, and kept separately in stoppered bottles. They do not improve by keeping, and therefore should be used as soon as possible after mixing. The proper amount of each ingredient being parcelled out and placed on a sheet of glass or paper, the whole is carefully mixed with a light hand by means of a bone or wooden knife, a common paper knife for instance. Chlorate of potash must be treated with especial caution, as it is very liable to explosion from friction whilst in contact with combustible matter.

Blue.—(*a*) Sulphur, sulphate of potash, and ammonio-sulphate of copper, of each 15 parts; nitre, 27; chlorate of potash, 28. For theatrical illuminations.

(*b*) Metallic antimony, 1 part; sulphur, 2; nitre, 5.

(*e*) Sulphate of copper, 7 parts; sulphur, 25; chlorate of potash, 69.

Crimson.—Chlorate of potash, $4\frac{1}{4}$ parts; alder or willow charcoal, $5\frac{3}{4}$; sulphur, $22\frac{1}{2}$; nitrate of strontia, $67\frac{1}{2}$. For pots.

Green.—(*a*) Charcoal and sulphide of arsenic, of each, $1\frac{3}{4}$ part; sulphur, $10\frac{1}{2}$; chlorate of potash, $23\frac{1}{4}$; nitrate of baryta, $62\frac{1}{2}$.

(*b*) Nitrate of baryta, 77 parts; chlorate of potash, 8; fine charcoal, 3; sulphur, 13.

(*c*) Metallic arsenic, 2 parts; charcoal, 3; chlorate of potash, 5; sulphur, 13; nitrate of baryta, 77.

Lilac.—Black oxide of copper, 6 parts; dry chalk, 20; sulphur, 25; chlorate of potash, 49.

Purple.—(*a*) Sulphide of antimony, $2\frac{3}{4}$ parts; black oxide of copper, 10; sulphur and nitrate of potash, of each, $22\frac{3}{4}$; chlorate of potash, 42.

(*b*) Sulphur, 12 parts; black oxide of copper, 12; chlorate of potash, 30.

Red.—(*a*) Sulphur, sulphide of antimony, and nitre, of each, 1 part; dried nitrate of strontia, 5.

(*b*) Chlorate of potash, 20 parts; sulphur, 24; nitrate of strontia, 56.

(*c*) Coal-dust, 2 parts; gunpowder, 6; sulphur, 20; dried nitrate of strontia, 72.

(*d*) Nitrate of strontia, $37\frac{1}{2}$ parts; flowers of sulphur, 10; charcoal, $1\frac{1}{4}$; powdered chlorate of potash, 5; black sulphide of antimony, $3\frac{1}{8}$.

Violet.—Charcoal, 8 parts; sulphur, 10; metallic copper, 15; chlorate of potash, 30.

White.—(*a*) Nitre, 60 parts; sulphur, 20; black sulphide of antimony, 10; meal-powder, 6; powdered camphor, 4.

(*b*) Gunpowder, $12\frac{1}{2}$ parts; zinc filings, 18; sulphur, 23; nitre, $46\frac{1}{2}$.

(*c*) Charcoal, 1 part; sulphur, 24; nitre, 75.

Yellow.—(*a*) Sulphur, 16 parts; dried carbonate of soda, 23; chlorate of potash, 61.

(*b*) Charcoal, 6 parts; sulphur, $19\frac{1}{2}$. For pans.

PYROTECHNIC MIXTURES:—

White Light.—Saltpetre, 8 parts; sulphur, 2; antimony, 2.

Red Light.—Nitrate of strontia, 20 parts; chlorate of potash, 5; sulphur, $6\frac{1}{2}$; charcoal, 1.

Blue Light.—Chlorate of potash, 9 parts; sulphur, 3; carbonate of copper, 3.

Yellow Light.—Nitrate of soda, 24 parts; antimony, 8; sulphur, 6; charcoal, 1.

Green Light.—Nitrate of baryta, 20 parts; chlorate of potash, 18; sulphur, 10.

Violet Light.—Nitrate of strontia, 4 parts; chlorate of potash, 9; sulphur, 5; carbonate of copper, 1; calomel, 1.

PHARAOH'S SERPENTS.—Fuse in a crucible equal parts by weight of yellow prussiate of potash and flowers of sulphur; it is frequently advisable, if the heat cannot be well regulated, to include a little carbonate of potash. Lixiviate the mass with water, and filter; the filtrate will be sulphocyanide of potassium, which, upon being added to a solution of mercury dissolved in nitric acid, gives a copious precipitate of sulphocyanide of mercury. Collect this; wash well with water, and dry; roll into a small pyramid, cover with tin foil, and when dry it is ready to .be lit.

FLOOR-CLOTH.

The main part of the manipulation is similar to calico-printing, the figures upon the blocks being upon a much larger scale, and the cloths which are printed being of much greater size. The common dimensions of a floor-cloth are 210 or 220 square yards. A stout canvas is chosen in the first instance. This is nailed to one extremity of a wooden frame, and stretched by means of hooks which are attached to the other side. It is then washed with a weak size, and rubbed over with pumice. No other substance has yet been found which answers the purpose so well as this mineral. The next step is laying on the colour, which is performed by placing dabs of paint over the canvas with a brush, and then rubbing or polishing it with a long peculiar-shaped trowel. Four coats of paint are thus applied in front, and three on the back of the cloth. To remove it from the frame when these processes are finished, a roller on the carriage is employed, upon which it is rolled, and conveyed to the extremity of the manufactory for the purpose of being printed. It is then gradually transferred from the roller and passed over a table which is 30 ft. long and 4 ft. wide, and as it proceeds over the table, the blocks, dipped in the appropriate colours, are applied. The colours used are ochre, umber, vermilion, and different kinds of chrome, mixed up with a little linseed oil and a little turpentine. The number of blocks applied to one pattern depends upon the number of colours. The first mode of applying the patterns was by stencil plates. Then a combination of stencilling and hand printing was used, the former process being first made use of; afterwards a block was applied, the stencilling forming the groundwork. Stencilling is now abandoned. In printing, it is necessary that the cloth should first be rubbed over with a brush, or else the colours will not adhere. Every square yard of good oilcloth weighs 3½ to 4½ lb., each gaining by the application of the paint 3 or 4 lb. weight, and hence the quality of this manufacture is judged of by the weight. Whiting mixed with oil is often used in spurious cloths. Cloth prepared in this way speedily cracks and becomes useless. Good cloth, with a very stout canvas, is used for covering verandahs, and will last nine or ten years, while spurious cloth will become useless in one year. Floor-cloth is employed to cover roofs, and for gutters. In the latter case it is remarkable that water remaining in contact with it produces no injurious effect. Painted baize for tables is usually manufactured with a smooth side, and is printed with blocks of a fine structure, resembling calico blocks. Fine canvas is employed; several coats of paint are laid on one side, and the other receives one coat, and is then strewed over with wool, or flocked, as it is called.

The manufacture of floorcloth has made rapid strides of late years, so that the foregoing description does not apply to modern works. For account of the industrial methods now adopted, the reader is referred to Spon's 'Encyclopedia.'

FLUXES.

In metallurgical operations the following articles are used as fluxes:—Crude tartar, if on a small scale, commercial cream of tartar, borax, nitre, sal ammoniac, common salt, limestone, glass, and fluor spar. These articles being easy to fuse, are added to substances which are more refractory, to promote their fusion.

Black Flux.—Nitre, 1 part; cream of tartar, 2; mix and burn in small quantities in a red-hot crucible; mix the product with finely-powdered charcoal. Keep in a dry corked bottle. This is used in smelting metallic ores.

Flux for Reducing Arsenic.—Carbonate of soda in crystals, 8 parts; finely-powdered charcoal, 1; heat gradually to a red heat.

Cornish Reducing Flux.—Crude tartar, 10 parts; nitre, 4; borax, 3. Powder together.

Refining Flux.—Crude tartar and nitre equal parts, burnt together.

Crude Flux.—Same as the black flux, omitting the burning in the crucible.

Flux for Arsenical Compounds.—(*a*) Dry carbonate of potash, 3 parts; cyanide of potassium, 1.

(*b*) Dry carbonate of soda and cyanide of potassium, equal parts.

Morreau's Reducing Flux.—Powdered glass, free from lead, 8 parts; and 1 part each of calcined borax and charcoal. Powder well, and mix together. (See also iii. 3, 297.)

FULMINATES.

Gold.—Add ammonia to a solution of terchloride of gold; the buff precipitate which it deposits is violently explosive at a gentle heat.

To make the terchloride of gold, dissolve gold in hydrochloric acid, with one-fourth of its volume of nitric acid. Evaporate on a water bath to a small bulk; when cool, yellow prismatic crystals of a compound of the terchloride with hydrochloric acid are deposited, from which the hydrochloric acid may be expelled by a gentle heat, not exceeding 250° F. The terchloride forms a red brown deliquescent mass, which dissolves very readily in water.

Mercury.—(*a*) This highly-explosive compound consists of protoxide of mercury united with an acid—fulminic acid, formed of cyanogen and oxygen. Fulminate of mercury is prepared by causing alcohol to react on the acid protonitrate. A quantity of mercury is dissolved in 12 parts of nitric acid of 35° or 40° B., and 11 parts of alcohol at ·86 sp. gr. are gradually added to the solution; while the temperature is slowly elevated, a lively reaction, accompanied by a copious evolution of reddish vapours, soon ensues, when the liquid, on cooling, deposits small crystals of a yellowish white colour. Fulminate of mercury is one of the most explosive compounds known, and should be handled with great care, especially when it is dry, and it detonates when rubbed against a hard body. It dissolves readily in boiling water, but the greater portion is again deposited in crystals during cooling.

The fulminating material of percussion caps is made of fulminate of mercury prepared as just stated, after having been washed in cold water. The substance is allowed to drain until it contains only about 20 per cent. of water, and is then mixed with $\frac{2}{5}$ of its weight of nitre, which mixture is ground on a marble table with a muller of guaiacum-wood. A small quantity of the paste is then placed in each copper cap and allowed to dry, the fulminating powder in the cap being often covered with a thin coat of varnish to preserve it from moisture.

(*b*) Weigh out 25 gr. of mercury in a watch-glass, transfer it to a half-pint pipkin, add a measured $\frac{1}{2}$ oz. of ordinary concentrated nitric acid sp. gr. 1·42, and apply a gentle heat. As soon as the mercury is completely dissolved, place the pipkin upon the table away from any flame, and pour quickly into it, at arm's length, 5 measured drachms of alcohol ·87 sp. gr. A brisk action will ensue, and heavy white clouds will arise. When this action has subsided, fill the pipkin with water, allow the fulminate to settle, and then pour off the liquid acid. Collect the fulminate on a filter, and wash with water as long as the washing tastes acid, then dry by exposure to the air. This explodes at a temperature of 360° F., or by being touched by a glass rod which has been dipped in concentrated nitric or sulphuric acid. An electric spark also explodes it.

Platinum.—Dissolve binoxide of platinum in dilute sulphuric acid, mix the solution with excess of ammonia; a black precipitate is obtained, which detonates violently at about 400° F.

Silver.—Dissolve 10 gr. pure silver, at a gentle heat, in 70 minims of ordinary concentrated nitric acid sp. gr. 1·42, and 50 minims of water. As soon as the silver is dissolved the heat is removed, and 200 minims of alcohol sp. gr. ·87 are added. If the nitric acid and alcohol are not of the exact strength here given, it may be difficult to start the action, in which case add two or three drops of red nitric acid, which contains nitrous acid. Standard silver, containing copper, may be used for the preparation of the fulminate. If the action does not commence after a short time, a very gentle heat may be applied until effervescence begins, when the fulminate of silver will be deposited in minute needles, and may be further treated as in the case of fulminate of mercury. As the fulminate of silver is exploded much more readily than the fulminate of mercury, it must be handled with the greatest caution when dry. It should be separated into small quantities, each portion wrapped in paper, and kept in a cardboard box; nothing harder than this should be brought in contact with it. This mixture is of no use for percussion caps, being too violent in its action.

Silver and Ammonia.—Dissolve fulminate of silver in warm ammonia: the solution, on cooling, will deposit crystals of the double fulminate. This is very violent in its explosion, and is dangerous while still moist.

GLASS.

Annealing.—This consists in putting the glass vessels, as soon as they are formed, and while they are yet hot, into a furnace or an oven, not so hot as to re-melt them, and in which they are suffered to cool gradually. It is found to prevent their breaking easily, particularly on exposure to heat. In large works, annealing is performed by passing the glass through the oven, by means of revolving trays constructed for the purpose.

Bending Tubes.—If a sudden bend is wanted, heat only a small portion of the tube to a dull red-heat, and bend it with the hand held at the opposite ends. If the bend is to be gradual, heat an inch or two of it in length, previous to bending it. If a gradual bend on the one side, and a sharp one on the other, as in retorts, a little management of the tube in the flame, moving it to the right and left alternately, at the same time that it is turned round, will easily form it of that shape. In bending glass, the part which is to be concave is to be the part most heated. An ordinary gas flame is quite sufficient to bend glass by, but that of a spirit lamp is better.

Cleaning.—Grease may be dissolved from glass by means of carbonate soda, carbonate of potash, or, better still, by caustic soda, made thus:—10 parts of carbonate soda are dissolved in 100 parts of water (10 oz. to 100 oz.), and heated to ebullition in a clean untinned iron vessel; 8 parts of good quicklime are meanwhile slaked in a covered basin, and the resulting hydrate of lime is added, little by little, to the boiling solution of carbonate, with frequent stirring. This will give a very strong caustic solution, and should be used with care. Keep your hands out of the solution, and dip the glass in by means of the pliers, keeping them moving while in the solution. When the grease is dissolved or loosened, scrub with a brush, well rinse in water, and dry. (See also ii. 120.)

Crystalline or Chipped.—Few trade secrets have been kept so well from the knowledge of the general public as the process of producing the abovementioned species of decorative glass. It is said to be the invention of a French engineer, who called it "vierre gievre," or frozen glass. In the United States, where its manufacture has been brought to a greater state of perfection than in any other country, it is known under the more common names of chipped or crystalline glass, and the operation of manufacture "glass chipping." It has a remarkable appearance, being covered with fern-like figures, no two of which exactly resemble each other, differing in both shape and form. To those unacquainted with the method of producing this glass—and there are very few that have any conception of how it is made—the process of manufacturing is very puzzling.

This method of ornamenting glass is so simple that most people, when they have it first explained to them, will hardly believe that such simple means can produce such marvellous results. It is done by covering glass with glue, which adheres to the glass, and when the glue dries it shrinks and draws with it pieces of the glass or chip of glass.

The first necessity in carrying out this process is to have the glass which is to be ornamented ground either by means of the sand-blast or by the more troublesome means of grinding by hand. This is done by rubbing a stone with a flat side over the glass till it has lost its polish and become translucent. A thin layer of emery, kept wet with water, will facilitate the grinding, which should be as coarse as possible, and for which reason grinding done by the sand-blast is preferable.

After the glass has been ground it should be kept scrupulously clean. Great care should be exercised that the surface is not touched by the hands. Any trace of grease is very apt to make the results uncertain. If the glass has, however, become contaminated, it may be cleaned with very strong ammonia, although glass which it has been necessary to clean is apt to be rather unreliable.

When everything is ready, the glass is placed in a room where it is intended to carry on the process, accurately levelled, and flowed with a solution made as follows:—

Good glue is placed in sufficient water to cover it, and allowed to soak for 24 hours. If the water is absorbed during the soaking, more may be added. It is then liquefied over a water-bath, and is then ready to use.

In practice it makes considerable difference which kind of glue is used. By repeated experiments it has been found that Irish glue is the best for the purpose.

A wide brush is dipped in the glue and applied to the glass. The coating should be a thick one, otherwise it will not be strong enough to do the work required. When the plates are coated, they may be placed in racks, and the temperature of the room raised to 95° or 100° F. They are permitted to remain at this temperature till they are perfectly dry, which will be in 10 to 20 hours.

It is at this stage that the uncertain character of glue shows itself. Under certain circumstances the glue will begin to crack and rise of itself without any more manipulations; but most generally it will require to have a stream of cold air suddenly strike it. If the plate is perfectly dry at this period, and of sufficient thickness, the top surface of the glass will be torn off with a noise resembling the crack of a toy pistol. Sometimes the pieces of glue will leap 2 or 3 in. in the air, and may even fly into the eyes and injure them. To guard against this it is customary for the workmen to wear a pair of spectacles fitted with plain glass. The glue will come off sometimes at the least expected times, notably if the plate with dried glue is being carried from one room to another. Plates which have shown a decided disinclination to chip have manifested a remarkable and unexpected activity, and have jumped into the face of the person carrying them in such a manner as to cause him to drop them.

The strength of the glue is something very extraordinary. If the glass has been coated on the hollow or belly side of the glass, the slight leverage thus obtained is almost sure to break it, especially if the glass be single strength. Even plate glass is not unfrequently broken. It might be a rather interesting mathematical calculation to find out the force necessary to separate the surface of glass in this manner on a piece, say, 48 in. by 48 in.

The result of the operation described may be various. It may be either a design resembling ferns of various shapes and sizes, or it may be a circular design, exhibiting narrow, feathery appearances; or, if unsuitable glue has been used, it may be of a nondescript appearance.

If, after the glue has been applied, but before it has become any more than set, a piece of stout paper is pressed over it and it is allowed to dry in this way, the glass will have less the appearance of feathers, but will be much coarser, and larger pieces will be removed.

The circular design mentioned occurs under the same circumstances as the other, with the exception that it generally is made during cold weather. Sometimes several weeks may run along and nothing but this formation be made.

Some very elegant designs may be produced by submitting the glass once more to the same operation, covering it as before and allowing the glue to chip. This is known by the name of double chip. If the glass was covered with the small circles in the first place, the second time it will have an appearance very much resembling shells, and for this reason this has been called shell chip.

If, instead of using ordinary glass, coloured glass is employed, pretty and original effects may be obtained. The glass may be either coloured clear through, or it may have only a thin coating on one side. In the latter case, in some places the entire layer of coloured glass will be removed, and in other places only a very little, and will, therefore, give all the gradations between those two extremes.

Glass which has been treated in this way may be silvered and gilded, and thereby be made still more remarkable in appearance.

Extremely elegant effects may be obtained by what is known as "chipping to a line." The design is ground in the glass by the ordinary sand-blast process. After the glass has passed through the machine, the protective coating (wax is generally used) is not removed, but is left on to keep the glue off those parts which are not intended to chip. The glue is then applied in a thick layer to the ground portion, and the process is carried on as usual.

Darkening.—The following, if neatly done, renders the glass obscure yet diaphanous:—Rub up, as for oil colours, a sufficient quantity of sugar of lead with a little boiled linseed oil, and distribute this uniformly over the pane, from the end of a hog-hair tool, by a dabbing, jerking motion, until the appearance of ground glass is obtained. It may be ornamented, when perfectly hard, by delineating the pattern with a strong solution of caustic potash, giving it such time to act as experience dictates, and then expeditiously wiping out the portion it is necessary to remove.

Drawing on.—Grind lamp-black with gum-water and common salt; draw the design with a pen or hair pencil; or use a *crayon* made for the purpose.

Drilling.—Glass can be drilled with a common drill, but the safest method is to use a brooch drill. No spear-pointed drill can be tempered hard enough not to break. The brooch can either be used as a drill with a bow, or by the hand. It should be selected of such a bore that it will make a hole of the required size, at about one inch from the end. It should be broken off sharp with a pair of pliers, at about 1½ inch, and when the sharp edges are blunted by drilling, a fresh end should be made by breaking off ⅛ inch, and so on, until the hole is bored. It is always desirable to drill from both sides, as it prevents the glass from breaking; drill lightly, and lubricate with spirits of turpentine and oil of lavender, or a little camphor instead of oil of lavender. Holes may be drilled through plate glass with a flat-ended copper drill and coarse emery and water. The end of the drill will gradually wear round, when it must be re-flattened, or it will not hold the emery. Practically, however, the best means of drilling holes in glass is by using a splinter of a diamond. A brass drill is made to fit the drill-stock, sawn down a little way with a notched knife to allow the splinter to fit tight, and the splinter fixed in the split wire with hot shellac or sealing-wax. The drill is used quite dry and with care. If the hole to be drilled is wanted larger than the tool, drill a number of small holes close together to form a circle as large as the hole required, then join the holes with a small file. A splinter of diamond may be bought for 2*s.* big enough to drill a $\frac{1}{4}$ in. hole. (See also iii. 231, v. 315.)

Etching.—(*a*) The ordinary embossing one sees on shop-doors, &c., is almost always done on plate-glass. A drawing on paper is first made; then by placing a piece of "transfer paper" (this can be bought at any artists' colour shop) under it and going over the design again, we obtain a reversed drawing on the other side of the paper. This is placed under the glass to work by. Those parts which are not to be acted on by the acid (hydrofluoric) are "protected" by a coating of Brunswick black, using a camel-hair brush. In a few hours or the next day a ridge of tallow is made around the design about $\frac{3}{4}$ in. high; the glass is placed perfectly level, and the acid is poured on to the depth of $\frac{1}{8}$ to $\frac{1}{4}$ in. When etched deep enough (a trial is made on a small piece of glass previously, as the time varies with the strength of the acid), in about ten minutes, pour off at one corner, wash with water, remove the black with turpentine, and clean well. The parts not acted on by the acid can now be ground with a small square of plate-glass and emery (medium). If the acid is too strong, it will not give sufficient time to pour on steadily. If it is too weak, it will require more than ten minutes. Good acid direct from the makers will take one-half water at least. The acid and water may be mixed in an ordinary clay pipkin, with handle such as used by gilders; but first melt some beeswax in it, and turn it about so as to give it a perfect coating, or the acid will eat its way through in a very short time.

Some very pretty effects are produced by what is known as "white" or "frosting" acid, used in conjunction with the ordinary hydrofluoric acid. For instance, we get out a design of a stork standing in the water among some rushes and water-lilies. The sky, water-lilies, and rushes may be frosted with the white acid, likewise some short horizontal lines on the water. The stork and the water may be done with the ordinary hydrofluoric, and will be semi-transparent. The outlines of all the objects must have a burnished line around them—that is, the feathers of the stork, the petals of the flowers, &c. The burnished line is clear glass that has been protected by the Brunswick black.

The method is to protect all the burnished outlines and all the parts intended to be frosted, then treat with hydrofluoric acid in the way previously described, then clean all off nicely, and protect all the outlines again and all the parts acted on by the acid, and then pour on the white acid; the white acid must not be diluted.

White acid is prepared by adding ammonia to strong hydrofluoric acid, together with a preparation of barium. The reason amateurs do not succeed in making it is, they cannot, as a rule, procure the fluoric acid strong enough.

White acid is the same material that is sold under the name of "diamond writing-ink" for writing on glass with an ordinary pen.

(*b*) *Cosmos* recommends the following for marking designs or inscriptions on glass bottles, &c.:—Dissolve about ·72 oz. fluoride of soda with ·14 oz. sulphate of potash in $\frac{1}{2}$ pint of water. Make another solution of ·28 oz. chloride of zinc and 1·30 oz. hydrochloric acid in an equal quantity of water. Mix the solutions, and apply to the glass vessel with a pin or brush. At the end of half an hour the design should be sufficiently etched.

(*c*) Another process, devised by Meth and Kreitner, of Berlin, is given in *Invention* as follows:—A mixture consisting of ammonium fluoride, common salt, and carbonate of soda is prepared, and then placed in a guttapercha bottle containing fuming hydrofluoric acid and concentrated sulphuric acid. In a separate vessel which is made of lead, potassium fluoride is mixed with hydrochloric acid, and a little of this solution is added to the former, along with a small quantity of sodium silicate and ammonia. Some of the solution is dropped upon a rubber pad, and by means of a suitable rubber stamp, bearing the design which is to be reproduced, is transferred to the glass vessel that is to be etched. (See also iii. 233, v. 5, 317.)

Frosting.—Roll up tolerably tightly a slip of tin, about 6 in. or 8 in. long and about 2 in. broad, or use a small flat piece of marble. Dip either of these in Croydon or glass-cutters' sand, moistened with water; rub over the glass, whether flat or round, dipping it frequently in a pail or pan of clear water. This is the method employed for frosting jugs, &c. For lamp glasses a wire brush is used, and they are chucked in a lathe. Panes of glass should be laid on a soft bed of baize, or coarse linen. If the frosting is to be very fine, finish with washed emery and water. As a temporary frosting for windows, mix together a strong, hot solution of sulphate of magnesia and a clear solution of gum arabic, apply warm. Or use a strong solution of sulphate of sodium warm, and when cool wash with gum-water to protect the surface from being scratched. (See also iii. 234, v. 319.)

Stencilling on.—Stencil plates may be cut out of thin sheets of metal or cardboard, in the same manner as for wall decoration, &c. If varnish colours are employed, lay them on as evenly as possible, through the perforations in the plate, and harden afterwards in a stove or oven. The metallic preparations used in glass staining and painting are also available, but require firing in a muffle, or a china-painters' stove. Should the process commonly called embossing be wanted, paint the portions of glass left uncovered by the spaces in the stencil plate with Brunswick black, dip or cover with hydrofluoric acid, wash in clear water and remove the black ground. Every part that was covered will then present a polished even surface, the remainder will have been eaten into by the acid. If the raised parts are to have a frosted appearance, rub them with a flat piece of marble moistened with fine emery and water. For putting patterns or lines on glass with a wheel, there are two methods, one followed by glass cutters, the other by the engravers on glass. According to the first-mentioned, rough in the pattern with an iron mill supplied with a trickling stream of sand and water, smooth out the rough marks on a wheel of York or Warrington stone, polish on a wooden wheel of willow or alder powdered with pumice, and finish on a cork wheel with putty and rottenstone. The engraver cuts in and roughs the pattern with copper wheels, aided by emery of various degrees of fineness, and olive or sperm oil, and polishes the portions intended with leaden disks and very fine pumice powder and water.

Transferring Engravings to.—Metallic colours, prepared and mixed with fat oil, are applied to the stamp on the engraved brass or copper. Wipe with the hand in the manner of the printers of coloured plates; take a proof on a sheet of silver paper, which is immediately transferred on the tablet of the glass destined to be painted, being careful to turn the coloured side against the glass; it adheres to it, and so soon as the copy is quite dry, take off the superfluous paper, by washing it with a sponge; there will remain only the colour transferred to the glass, which will be fixed by passing the glass through the ovens.

Windows.—*Crown glass* is made in circular disks blown by hand; these disks are about 4 ft. diameter, and the glass averages about $\frac{1}{15}$ in. thick. Owing to the mode of manufacture, there is a thick boss in the centre, and the glass is throughout more or less striated or channelled in concentric rings, frequently curved in surface, and thicker at the circumference of the disk. Consequently in cutting rectangular panes out of a disk there is a considerable loss, or at least variety in quality: one disk will yield about 10 sq. ft. of good window glass, and the largest pane that can be cut from an ordinary disk is about 34 × 22 in. The qualities are classified into *seconds*, *thirds*, and *fourths*.

Sheet glass is also blown by hand, but into hollow cylinders about 4 ft. long and 10 in. diameter, which are cut off and cut open longitudinally while hot, and therefore fall into flat sheets. A more perfect window glass can be made by this process, thicker and capable of yielding larger panes with less waste. Ordinary sheet glass will cut to a pane of 40 × 30 in., and some to 50 × 36 in. It can be made in thicknesses from $\frac{1}{20}$ in. to $\frac{1}{2}$ in.

Plate glass is cast on a flat table and rolled into a sheet of given size and thickness by a massive metal roller. In this form, when cool, it is *rough plate.*

Ribbed plate is made by using a roller with grooves on its surface. Rough and ribbed plate are frequently made of commoner and coarser materials than polished plate, being intended for use in factories and warehouses.

Polished plate is rough plate composed of good material and afterwards polished on both sides, which is done by rubbing two plates together with emery and other powders between them. Plate glass can be obtained of almost any thickness, from $\frac{1}{8}$ in. up to 1 in. thick, and of any size up to about 12 × 6 ft.

In the glazing of a window the sizes of the panes, that is to say, the intervals of the sash-bars, should be arranged, if practicable, to suit the sizes of panes of glass which can conveniently be obtained, so as to avoid waste in cutting; this consideration is of more consequence in using crown and sheet glass than with plate glass. The woodwork of the sash should receive its priming coat before glazing, the other coats should be put on afterwards. With crown glass, which is sometimes curved, it is usual to place the panes with the convexity outwards. When the glazier has fitted the pane to the opening with his diamond, the rebate of the sash-bar facing the outside of the window, he spreads a thin layer of putty on the face of the rebate and then presses the glass against it into its place, and, holding it there, spreads a layer of putty all round the side of the rebate, covering the edge of the glass nearly as far as the face of the rebate extends on the inner side of the glass, and bevelling off the putty to the outer edge of the rebate. The putty is then sufficient to hold the pane in its place, and hardens in a few days. The glass should not touch the sash-bar in any part, on account of the danger of its being cracked from any unusual pressure; there should be a layer of putty all round the edges. This precaution is especially necessary in glazing windows with iron or stone mullions or bars.

GRAINING.

GROUNDS.—These are generally applied by the house painter, ready for the grainer. When the grounds are finished to the tint required for the woods to be imitated, they must be left to get quite dry; the work is then ready for the graining operations.

COLOURS.—The colours used to give the various effects are as follows:—

Bird's-eye Maple and Satin Wood.—White-lead mixed with a little yellow ochre, care being taken not to make the ground of too dark a tint, as the varnish to be afterwards applied will still further darken it. All the colours for light grounds must be rubbed quite smooth, and be well strained.

Mahogany.—Orange chrome, Venetian red, and white-lead mixed in such proportions as will give the desired tint. Vermilion, raw and burnt sienna, are also employed to modify the shades.

Oak.—Dark.—(*a*) Raw sienna, burnt umber, white-lead, and Venetian red.

(*b*) Yellow ochre, Venetian red, and white-lead.

Dark wainscot.—Oxford ochre, white-lead and Venetian red; or chrome, yellow ochre, and white-lead.

Light.—Yellow ochre and white-lead;

the desired tint is obtained by the use of more or less of the yellow ochre.

Rosewood.—Vermilion, Venetian red, a little scarlet lake, and white-lead. For ordinary work the scarlet lake may be dispensed with.

STYLES. — *Bird's-eye Maple.* — (*a*) Graining colour—equal parts of raw sienna and burnt umber mixed in ale, of two thicknesses. First lay on an even coat of the thinner mixture, then with a smaller brush put in the darker shades, mottle and soften with a badger-hair brush. The eye is imitated by dabbing the colour whilst still wet with the tops of the fingers. When dry, put on the top grain in the most prominent places, and shade the eyes with a little burnt sienna. Some grainers use small brushes called maple eye-dotters, instead of the fingers, for forming the eyes. Various forms of brushes are used for the mottling; some consist of short camel hair closely set, whilst to give the wavy appearance hog-hair mottlers are used, with long hairs, against which the fingers are pressed as the brush is drawn over the work, causing it to assume a variety of pleasing curves. The lines to imitate the heart of the wood are put in with a small brush, and the outer lines parallel to the heart are formed with the overgraining brush. Overgraining brushes for maple consist of a number of small sable brushes mounted at a little distance from each other in a frame, and resembling a comb in its appearance.

(*b*) Grind equal parts of raw and burnt sienna in a mixture of water and ale. Coat the work evenly with this colour, then rub it down with a long piece of buff leather, cut straight at the edge and pressed closely against the work. Proceed for the imitation of the eyes and heart of the wood as before directed.

(*c*) For outside work grind the raw and burnt sienna with a little of the patent driers, and then with boiled oil. Lay on an even coat, and rub down with a piece of buff leather. Soften, and when dry put on a top grain of burnt umber and raw sienna ground in ale.

(*d*) Burnt umber or Vandyke brown laid on unevenly, darker in some places than in others, after the character of the wood; a coarse sponge does for this purpose very well.

When the colour is disposed over the surface, it must be softened down with the badger-hair tool, and the knots put in with the end of a hog's-hair fitch, by holding the handle between the thumb and finger, and twisting it round; these knots may be afterwards assisted by a camel-hair pencil. A few small veins are frequently found in maple; these may be wiped off with a piece of wash-leather. When this is dry, the second or upper grain may be put on; some of the first colour diluted will do for this second grain. To put on this grain, use the flat hog-hair brush, and the hairs combed out to straighten or separate them. As soon as the grain is put on, the softener should be passed lightly across the grain in one direction only; this will make one edge of the grain soft and the other sharp, as it occurs in the wood. After the second grain is dry it may be varnished.

Hair-wood.—(*a*) First lay on a coat of light grey, of white-lead ground in boiled oil, add a little Prussian blue, and mix with turpentine. For ground colour use the same paint made much thinner with turpentine, laid on as soon as the first coat is dry. The ground colour must only be applied on a small piece at a time, as it must be grained before it dries. For the graining use some of the ground colour, to which add a little Prussian blue, apply this with a feather, in long veins. Overgrain with the ground colour.

(*b*) Mix white-lead and turpentine, and add a little Prussian blue, for the ground colour. For the graining colour, Prussian blue and raw sienna ground in ale. When the ground is dry, lay on a thin coat of the graining colour and soften; put on the long grain with a mottler drawn across the work. Soften, and overgrain in a perpendicular but wavy figure.

Mahogany.—(*a*) Vandyke brown and a little crimson lake ground in ale laid on, allowed to dry and then smoothed, forms the ground. Then lay on a second thicker coat, soften with a badger-hair brush, take out the lights whilst it is wet, and imitate the feathery appearance of mahogany heart. Soften, and top grain with Vandyke brown laid on with an overgraining brush of flat hog-hair combed into detached tufts. In softening, be careful not to disturb the under colour.

(*b*) Grind burnt sienna and Vandyke brown in ale, lay on a coat, mottle with a camel-hair mottler, and soften. When dry, overgrain as above.

Oak in Distemper.—This process is now seldom used, although it stands exposure to the weather, without fading, for a great length of time. For colour, dissolve gum arabic in hot water, and make a mixture of it with whiting, raw sienna, and Vandyke brown ground in beer. Colour the work evenly, brush it down with a dry dusting brush, comb while the colour remains wet, then let it get quite dry. Put in the veins with a small brush dipped in clean cold water. After a few seconds, run a dry soft duster down the work to remove the colour from the veins. Then lay on a thin coat of Turkey umber ground in beer. Put on with an overgraining brush. If too much gum is put in the colour it is likely to crack and blister; whilst if there is not sufficient, the veins will not be clearly marked by the wiping out.

Oak in Oil.—Vandyke brown and raw sienna for dark oak, or finely-ground burnt umber and raw sienna for a lighter tint, mixed with equal parts of turpentine and linseed oil. Add patent driers. Lay this colour on thinly and evenly with a large brush; it does not dry very rapidly. Care must be taken not to lay on too much colour, or it is liable to have a dirty appearance. Stipple with a dry dusting brush, so as to distribute the colour evenly over the work. As in real oak it is invariably found that one side of a slab is coarser than the other, this peculiarity of pattern must be imitated in the combing process. Take a cross-cut gutta-percha comb, and draw it down one side of the panel; use a finer comb to complete it. This operation produces straight lines of the grain from top to bottom. Next take a fine steel comb, and go over all the previous combing; in drawing the comb down, give it a short, quick, wavy motion, or move it diagonally across the first lines, thus imitating the pores of the real wood. Cork combs may also be used, and some grainers use a coarse steel comb, with a fold of thin rag placed over the teeth. By a skilful combination of the combs, and a tasteful variation in their use, the different kinds of oak may be most successfully imitated. In graining joints of the various portions of a piece of work, it must be remembered that in the real wood some of the grain would necessarily have a perpendicular direction, and another part would run horizontally, and that one part would appear lighter than another, owing to the different angles in which it would receive the rays of light. After combing, the figure or veining must be wiped out before the colour is dry. Hold several thicknesses of fine rag, or a piece of clean wash-leather over the thumb nail, wipe down a few veins, then move the rag or leather slightly, so as to present a clean surface for the next wipe. A piece of thin gutta-percha, softened in warm water, and pressed to the shape of the thumb, may be used to preserve the nail, but cannot be relied on to remove the colour so cleanly as the nail covered with rag or leather; it is useful for common work, as it protects the nail from injury and wear. After having wiped the figures, they must be softened in appearance by still further wiping the grain away from their edges with a small roll of clean rag, so as to imitate the appearance of the wood, where the grain is always darker than the parts next to it. When the oil colour is dry it must be overgrained.

Oak in Spirit Colour.—This is less durable than oak graining in oil, and is not therefore so much used for outside work, but it does not require so long a time in its working, as it dries rapidly.

For the graining colour, rub up whiting in turpentine, add enough burnt umber and raw sienna, dilute with turps, a little boiled oil, and gold size. Strain carefully, and it is ready for use. In laying this on, cover only a small part of the work at a time before combing, as it dries very quickly, and be careful to spread it evenly and thinly over the work. The combs used are made of steel, horn, or leather. After combing the veins and removing any superfluous graining colour from corners or small parts of the work, let it stand for a short time. The flower of the wood has next to be imitated, by removing some portions of the graining colour with a small veining fitch. The spirit graining colour when used for this purpose must have a little turpentine added to it; apply with the fitch where the flower is required, then rub the places quickly with a piece of old flannel, which will remove the graining colour and show the light ground underneath. The light veins and half-lights are also obtained by similar means, either removing the graining colour or merely smudging it aside over the veins. The overgraining is performed in the manner described for the oak graining in oil.

Pollard Oak in Distemper.—The ground is a mixture of vermilion, chrome yellow, and white-lead, to a rich buff. The graining colours are Vandyke brown, a little raw and burnt sienna and lake, ground in ale. Fill a large tool, lay on an even coat, and soften with the badger-hair brush. Take a moistened sponge and dapple round and round in circles, then soften lightly, and draw a softener from one set of circles to the other while wet, to form a number of grains; finish the knots with a hair pencil. When dry, put the top grain on in a variety of directions, and then a coat of turpentine and gold size mixed. When this is dry, glaze with Vandyke brown mixed in beer.

Pollard Oak in Oil.—Ground, the same as for pollard oak in distemper. Graining colours, equal portions of Vandyke brown and raw sienna, ground separately in boiled oil very stiff; mix them together, and thin the whole with spirit of turpentine. With a large brush lay on a thin coat, and, while wet, take the flat graining brush dipped in the colour, and dapple in various directions; then dip the brush into burnt umber thinned with spirit of turpentine, and form the knots. When the colours are set, dip a flat brush into a thin glaze of burnt umber, and put the grain on in a curly direction. Have enough oil in the colours to bind them, and finish only a small part of the surface at once, in order to keep it moist. For making the knots a cork should be held on to a patch of the dark colour, and twisted round between the thumb and finger. The heart of the wood should be taken out with a graining fitch.

Rosewood.—Ground: chrome yellow, vermilion, and white-lead. For the graining colour, grind ivory black and burnt sienna very fine; mix, and lay on; then soften. When dry, put on the top grain in a curly figure, with a small graining brush well filled with ivory black. Shade up the knots with a camel-hair brush, and finish with a glaze of rose-pink.

Satin Wood.—(*a*) Graining colour.—Equal parts of raw umber and raw sienna, a little whiting and burnt sienna, all ground in ale. Colour evenly, and soften; then mottle and feather same as for mahogany. Soften, and allow to dry; overgrain with the same colour.

(*b*) Grind raw sienna and whiting in ale very thin, and colour the surface. Soften whilst wet, and take out the lights with a mottling brush; when dry, overgrain with the same colour applied with a flat brush.

Yew.—Ground, reddish yellow. For graining colour, grind equal parts of Vandyke brown and burnt sienna in ale, with a little raw sienna. Lay this colour on evenly when the ground is dry, and soften. Cut a piece of cork to a tolerably sharp edge, rub it across the work, and soften the same way as the grain, as in curled maple. When dry, dab the work over with the graining colour on the tips of the fingers to form the knots; shade them underneath with a camel-hair brush. When dry, overgrain.

Graining Roller.—This tool consists of a roller of wood or metal mounted on a spindle, to which are attached a frame and a handle. Around the wooden roller is a wrapper of leather, on which is cut or stamped an imitation of the grain of a certain wood. The leather used for the roller is of thick hide. The pattern is sketched on one side, and then the ground is cut away to a certain depth, just as a block cutter would do for printing. In some cases the strip of leather is made fast to the roller, and only just covers it; in other cases the leather will be three or four times the circumference of the roller. The distemper graining colour is brushed over the work to be grained, and, while it is wet, the roller, which has previously been damped with a wet chamois leather, is passed over it, and as the roller passes along it takes up the colour in patches of the exact shape of the pattern on the roller used. This is then softened with the badger-hair softener, and overgrained. By a judicious use of these rollers, using only a part of the circumference, and changing the direction, the patterns may be obtained in great variety. The mottle of satinwood, mahogany, ash, and birch is well imitated by these rollers, and also the beautiful feathers or curls in mahogany and satinwood. The mottle of these woods has very little variety, so that one or two patterns suffice for all; and this class of woods is peculiarly suitable for imitation by these rollers. To use the rollers for the imitation of mahogany, satinwood, birch, and maple, lay the colour, mixed in beer, on the surface, pass the roller over it whilst it is wet, soften, and overgrain with a hog-hair overgrainer, previously combed to separate the hair. The roller should occasionally be passed twice over the same place, and in some parts plain spaces left, so as to prevent a repetition of the patterns. Put in the maple eyes by hand in the usual way. Before overgraining the graining should be covered with a coat of turpentine, gold size, and a little varnish to bind it, so that the colour may not be removed by the overgraining. For oak, lay the colour on as regular as possible, and comb as in ordinary work, a little common flour paste being added to the water colour, to enable it to stand the comb. Then pass the roller over it, and the badger, in the same direction as the combing. Overgrain same as mohogany, after the application of the mixture of gold size, varnish, and turpentine. The rollers must be kept quite clean, and free from grease or oil. Before commencing work wet the rollers thoroughly with a sponge and water, and rub them with a wash-leather or dry cloth, so as to remove any water remaining on the surface. Whilst using the rollers, have a piece of wash-leather at hand, over which they should be frequently passed to keep them quite clean, and prevent the accumulation of colour on their surfaces, which would clog up the pattern. After use, wash them well with a brush and water, and let them dry gradually; do not apply heat, as that is likely to crack the surface.

Overgraining.—(*a*) This operation is performed in the same manner whether the work has been oil grained or spirit grained. In overgraining, watercolours are used; and, in order to make them adhere to the underlying graining, whether in spirit or in oil, it is necessary to prepare the work to receive them, otherwise they would run off the surface at once. One method is to rub dry powdered whiting quickly over the surface with a soft rag, removing superfluous powder afterwards, and the grainer can at once finish the work. Another plan, which is principally used when a large piece of work is in hand, is to rub a mixture of fullers' earth and water over the graining, and wait until it is perfectly dry before commencing to overgrain. Grind Vandyke brown, or burnt umber, in water, and thin with equal proportions of water and beer. The colour should be a trifle darker than the undergraining; a little practice will teach the tints that are best suited to the various woods to be imitated.

The colour is applied by a wide hog brush, drawn over the work, generally in the direction of the veins formed by the combing. There are several descriptions of overgraining brushes in use; those most generally employed are thin and flat, with occasional intervals between the tufts of hair. The knots and figures must be lightly touched up with the overgrainer, and the whole gone over quickly with a badger softening brush. The overgraining dries quickly, and the varnish may be then applied, although it is well to wait some hours, so as not to run any risk of removing the graining colour. Sometimes a tolerably strong solution of soda with a little burnt sienna is used for the figures, applying the mixture where these are required, and then washing over the work with a sponge and water. Wherever the soda has been applied, the graining colour will be removed. Go over the whole with a wash made of equal parts of beer and water, and then overgrain, as above described. As a general rule, avoid harsh contrasts between the graining colour and the ground.

(*b*) In the mixing of oil graining colour, it is necessary that the colour should work clean and free. Sometimes the colour will work stiff and dirty, and in this state will not only produce dirty work, but will occupy thrice the time in rubbing in, compared with colour properly mixed. Oil graining colour also requires to be megilped—that is, oil colour alone will not stand when it is combed; the marks made with the comb will all run one into the other, and will thus be obliterated. To prevent this running, the colour requires to be megilped, so that the comb marks will retain the exact form left by the comb. This is accomplished by the use of beeswax, soft soap, hard soap, lime water, whiting, and pure water. When beeswax is used, the best means of dissolving it is to cut the wax into thin shavings or shreds; these are put into a suitable can half filled with pure linseed oil, into which a red-hot poker is plunged, and stirred well. This will dissolve the wax thoroughly and mix it with the oil. When the wax is all dissolved, the vessel should be filled with either oil or turpentine, which further dilutes and mixes the wax, and serves also to prevent it from congealing, so that it may mix with the graining colour thoroughly. This should be seen to, or else the wax is apt to remain in lumps; and when the colour is spread upon the work, for graining, the wax will be spread unequally, and will not dry in parts, so that it is absolutely necessary that the wax should be thoroughly mixed with the graining colour to produce good work. If soft soap is used, it should first be thoroughly worked up on a palette or a board with either whiting or patent driers; this breaks up the soap, and amalgamates it with the driers, and it will then mix properly with the graining colour. Another method is to break up the soft soap in water to a thick froth or lather; in this state it may be beaten up with water and thoroughly mixed with the oil colour. When the lime water is used, about 2 lb. of slaked lime should be thoroughly mixed in a pint can full of water, and the lime allowed to settle; a portion of the water may then be added to the graining colour, and the two well stirred together until they are thoroughly amalgamated. If whiting is used, it should be ground in oil, and then mixed with the graining colour. Pure water will also answer the purpose. The wax is the most effectual, but there are some objections to its use. On the whole, pure water is preferable, for if it is well mixed with the oil colour, it megilps it sufficiently to hold the combing until it sets; the water then evaporates and leaves no injurious effects behind, and the projection of the grain is less than it is if any other medium is used.

The most useful colours for mixing oak-graining colour are raw and burnt Turkey umber, Oxford ochre. Vandyke brown, and burnt sienna. The first three, with the addition of ivory black, are all that is required for mixing any shade of graining colour. For light oak or wainscot graining colour, mix

$\frac{2}{3}$rds linseed oil with $\frac{1}{3}$rd turpentine; add a little Oxford ochre and raw Turkey umber in sufficient quantity, according to the shade required and amount of stuff mixed. Terebine or liquid driers should be added, the quantities being regulated according to whether the graining colour is required to be quick or slow drying. A safe quantity to use, if the liquid drier is of the best quality, is about $\frac{1}{2}$ oz. to a pint of colour. This will cause the colour to dry in about 7 or 8 hours, but twice the quantity may be used with safety if the colour is required to dry very quickly. Sugar of lead ground in oil may be used as a drier for graining colours, but the liquid drier is better. After adding the liquid driers, beat or stir well up together; add pure rain water in the proportion of $\frac{1}{2}$ pint of water to 3 pints of oil and turps; beat or stir up until the whole is thoroughly mixed together, after which strain through a fine strainer or a double fold of fine muslin. The colour should be thinned until it works freely and lies on well, so that when the colour is being brushed over the work to be grained, it will lie on evenly, and be easily spread, and will look clean and of one uniform shade of colour. Care and cleanliness of working are necessary to the successful carrying out of this work; and it is essential that the colour, the brushes, and all working tools should be clean to begin with, and be kept clean.

MARBLING.—*Black and Gold Marble.*—Ground, deep ivory black. Put on veins of white-lead, yellow ochre, and burnt and raw sienna, with a camel-hair brush. The spaces between the veins must be glazed over with a thin coat of grey or white, over which pass a few white veins. The veins may also be put on with gold leaf. Another method is to have a yellow ground, streaked with broad ribbons of black, in which fine veins are obtained by drawing a sharp piece of wood along them whilst wet, so as to expose the yellow beneath.

Black and White Marble.—White ground, and with dark veins, put on with a marbling crayon, and softened while the ground is wet. Or, when the ground is dry, cover it with a thin coat of white-lead, and put the veins in with a camel-hair pencil. Blend while wet.

Blue and Gold Marble.—Ground, a light blue; when dry, take blue with a small piece of white-lead and some Prussian blue, and dab on in patches, leaving portions of the ground to show between. Blend together with a softener; next put on white veins in every direction, leaving large open spaces to be filled up with a pale yellow or gold paint. Finish with fine white irregular threads.

Dove Marble.—Ground, lead colour, of which it will be necessary to give two or three coats. If the work is new, let it dry hard, rub it smooth with fine glass-paper after each coat, and do not rub the paint off the sharp edges of the wood. For the marbling, take lead colour such as used for the ground, thin it with turpentine, and rub a light coat over a small part of the work; and with a whitish colour form the small specks or fossil remains. Proceed, piece by piece, till the whole surface is covered, being careful to paint but a small part of the ground at once, so that the colours may have sufficient time to blend together while wet, otherwise the work will appear harsh. Then with a small sash tool, put in faint, broad veins of the thin ground colour, and numerous very fine veins over the whole surface of the work, crossing each other in every direction. Then make the colour a little lighter, by adding white-lead, and with a feather pass over the broad veins in the same direction, forming streams of threads. With thin white, and with a camel-hair pencil go partly over the same vein with short thick touches, then with a fine striping pencil. When the work is hard, it should be smoothed with very fine glass-paper before being varnished. The first layer of veins should be very faint, so as to be scarcely perceptible; for, as the lighter shades are put on, the former veins will appear sunk from the surface of the work, which will give a good effect where the work is exposed to close inspection.

Granite.—(*a*) Grey ground, with white and black spots.

(*b*) Venetian red and white for the ground, with white, black, and vermilion spots.

The spots are put on in several ways; a sponge may be charged with the marbling colour and dabbed on the work, or a common brush may be struck against a stick held at a little distance from the work, so as to throw off blots and spots of colour.

Italian Marble.—Ground, a light buff. For marbling, mix stiff in boiled oil white-lead, Oxford ochre, and a little vermilion; grind burnt sienna very fine in boiled oil, and put it into another vessel; mix pure white stiff in oil, and keep this also separate. Thin these colours with turpentine, and have a brush for each. Take the buff brush moderately full of colour, and dab it on in patches, varying as much as possible; take another brush and fill in the spaces between with sienna. With a softener blend the edges together, making them as soft as possible. Draw a few thin white veins over the work with a hair pencil, run in a few thin lines of sienna, and soften.

Jasper.—Mix the ground the same as for mahogany, with red-lead, Venetian red, and a little chrome yellow, thinned with equal parts of oil and turpentine; lake or vermilion may be substituted for the Venetian red, if a brilliant tint is desired. Whilst the ground is wet, dab on some spots of white, soften with a softening brush, and other colours may be applied in the same manner. When dry, put on the veins with a camel-hair brush.

Porphyry.—(*a*) Ground, purple-brown and rose-pink. Grind vermilion and white-lead separately in turpentine, and add a little gold size to each colour to bind it. More turpentine must be added before the colour is applied. When the ground is dry, fill a large brush with vermilion, squeeze out nearly all the colour by scraping the brush on the edge of the palette knife; hold a rod in the left hand, strike the handle of the brush against it, so as to throw small red spots on to the work till the surface is covered. Make the colour lighter by adding white-lead, and use as before. Then with clear thin white throw on very fine spots, and when dry put in a few white veins across the work. This marble may be imitated in distemper in precisely the same manner as in oil.

(*b*) The ground is Venetian red, with a little vermilion and white. For marbling, add a little more white to the ground colour, and sprinkle over the first coat. When dry, repeat the splashing with a mixture of Venetian red and vermilion, and then with white in very fine spots. Form opaque white veins across the work, and transparent threads in various directions. This must be done when the work is dry and hard, with a sable pencil, and the threads drawn with a feather. For each separate colour use a different brush.

Sienna Marble.—(*a*) Ground, Oxford ochre and white-lead. Use burnt and raw sienna, white, black, and a little lake, for marbling. These colours should be laid on as a transparent glaze, and marked and softened while wet. The colours should be properly softened with a badger brush.

(*b*) Ground, raw sienna or yellow ochre. When dry, mix raw sienna with white-lead, have ready also some white paint, put in broad transparent tints of hite and yellow, and while wet blend them together with a softener. Mix Venetian red and a little black, and put in some broad veins in the same direction as the patchy tints run; for the darker veins take a mixture of Venetian red, lake, and black, and draw them over the first layer of veins with a feather, in fine threads, running to a centre, and in transparent veins in different directions. Mix some Prussian blue and lake, and put in the darkest and finest veins over those before laid on. Put in a few touches of burnt sienna between the fine veins, which are formed into small masses. All the colours should be ground in spirit of turpentine, and mixed with sufficient gold size to bind them.

Verde Antique.—If the work is new, lay on a coat of dark lead oil colour. When dry, smooth with glass-paper, and lay on a coat of black paint. When the ground is dry, mix some white-lead with water and a little beer. Lay this on in large streaks. Fill up the spaces left with veins of lampblack, finely ground in beer, thus covering the whole surface of the work. While still wet, soften with a badger-hair brush, so as to cause the veins to run into one another. On the darkest parts of the work lay dabs of white, carelessly applied, to imitate fossils, and dab over the light parts of the work with the black colour for the same purpose. With a thin flat graining brush, or a feather, dipped in the white, form small veins over the black; a few dark blue wavy veins may also be put on. When dry, glaze with a thin coat of raw sienna and Prussian blue, ground in spirit of turpentine and mixed in copal varnish. A little emerald green added here and there heightens the effect.

Verde Antique, Oriental.—Lay on a ground of black in oil. Mix white-lead in oil, thinned with turpentine for the graining colour. Lay this on in broad transparent veins of irregular depth of colour, and whilst wet dab it over with a piece of wash-leather in different parts to imitate fossils; then with a small piece of cork, twisted round on the work between the finger and thumb, produce a number of little spiral figures of various sizes and shapes. Cut notches on the top of a feather, dip it in the white, and pass it over the black ground in zigzag and fantastic veins, with occasional sharp angles. Let all the work get quite dry, and then glaze with green, in some parts with Prussian blue, in others with raw sienna, leaving some portions untouched. When dry, wash with beer, dip a feather into the whiting ground, and draw fine veins. To finish, give a coat of glaze, made of a little Prussian blue and raw sienna, mixed in equal parts of boiled oil and turpentine, leaving some of the white veins unglazed.

GUN-COTTON.

There are several varieties of gun-cotton—the explosive, soluble only in acetic ether; pyroxiline, soluble in sulphuric ether and alcohol; and xyloidine. All these are formed by the action of nitric acid on cotton or lignine in some form. The difference between them consists mainly in the strength and temperature of the acids employed in their preparation. The most explosive is prepared with the strong acids, sulphuric and nitric, mixed, the object of the sulphuric being to take water from the nitric, and so leave the latter in its full strength to combine with the lignine or cotton.

(*a*) The first thing to be done is to thoroughly cleanse the raw material. This is effected by boiling it in an alkaline solution, then drying it in a current of air, and then again boiling it in clean water. After the second boiling it must be very thoroughly dried at about 120° F. The cotton must be very thoroughly dried, as any moisture which might remain in it would, by combining with the acid, generate heat, and set up a destructive action. The cotton, in charges of 1 lb., is placed separately in a bath containing the mixed acids, the mixture in which the cotton is submerged consisting of 3 parts by weight of Nordhausen sulphuric acid sp. gr. 1·84, and 1 part of nitric acid sp. gr. 1·5; this mixture is allowed to cool down—a process which occupies two or three days—before the cotton is placed in it. After immersion, the charges of cotton are strained until each contains only about 10 times its weight of acids, and each charge is then placed in an earthenware jar and covered down. In order to prevent any heating from taking place, the jars should be placed in a current of cold water. The cotton after being exposed to the acid for 48 hours, in order to ensure its thorough conversion, is removed from the jars and squeezed nearly dry. It is then to be suddenly plunged into a strong fall of cold water, and left for a short time.

The object of placing the gun-cotton in the fall of water is to ensure the sudden and complete submersion of the material, and thus avoid the heating and decomposition of the cotton, which would take place at the surface of the water if the cotton were immersed gradually. On its removal from the fall of water, the gun-cotton is wrung dry, and placed in a stream of water for 48 hours. After being washed and partly dried several times more, the cotton should be thoroughly dried at the temperature of no more than 140° F. It is now so explosive that great care is required in its arrangement, being about three times as explosive as gunpowder. As thus prepared gun-cotton scarcely differs from unchanged cotton in appearance; it is white and fibrous, and rather harsh to the touch.

(*b*) If only a small quantity is required—Mix 4½ oz. of pure, dry, nitrate of potash with 30 fl. dr. of sulphuric acid sp. gr. 1·845, and stir into this mixture carefully 120 gr. of best carded cotton. As soon as saturation is complete, in about one minute, if proper care has been used, throw the cotton into a large pan of clean rain water, and change the water repeatedly until litmus ceases to show the presence of acid, then squeeze it in a cloth, and, after being well pulled out, dry it at a temperature of about 180° F.

(*c*) Take 1 oz. of cotton, 5 fl. oz. sulphuric acid, 5 fl. oz. nitric acid; mix the acids in a porcelain mortar, immerse the cotton in the mixture, and stir it for three minutes with a glass rod; decant the liquid, pour more water on the mass, and repeat the process until the washing ceases to give a precipitate with chloride of barium. Drain the product on filtering paper, and dry in a water bath.

For more detailed information of the manufacture on a large scale, the reader is referred to Spons' Encyclopædia.

GUNPOWDER.

The component parts of gunpowder are saltpetre, sulphur, and charcoal, used in the following proportions:—

(*a*) English war powder.—Saltpetre, 75 parts; sulphur, 10; charcoal, 15.

(*b*) French war powder.—Saltpetre, 75 parts; sulphur, 12·5; charcoal, 12·5.

(*c*) French sporting powder.—Saltpetre, 76·9 parts; sulphur, 9·6; charcoal, 13·5.

(*d*) French blasting powder.—Saltpetre, 62 parts; sulphur, 20; charcoal, 18.

There are a number of variations of the above; but the difference, which is purely a matter of opinion, consists principally in varying the quantity of sulphur or charcoal employed.

Saltpetre.—Crude saltpetre cannot be used for making gunpowder. The crystalline flour, quite free from chloride, is the best for the purpose. The washing process is carried so far that nitrate of silver produces no precipitate in the purified saltpetre. The general rule is to use the saltpetre whilst slightly damp, allowing for the proportion of moisture when mixing with the other ingredients. This saves the processes of drying and grinding the saltpetre before mixing with the sulphur and charcoal.

Sulphur.—Refined sulphur in rolls is used. This must be reduced to an impalpable powder, which is usually effected by placing the sulphur in hollow wooden drums having projections or brackets inside. A number of small brass balls are put into the drum with the sulphur, and the drum is made to revolve for six hours, when the action of the balls and projections reduces the sulphur to very fine powder, which is then extracted through wire gauze. Any small particles of sand, or unequally pulverised sulphur, are then separated by a bolting machine.

Charcoal.—The quality of the charcoal depends greatly upon the material from which it is obtained, and the manner in which it is prepared. The soft, woody parts of plants, which yield a friable, porous charcoal, leaving very little ash, are preferred. Black alder, spindle tree, poplar, chestnut, vine-stalks and willow, are most esteemed. Hemp-stalks, fibres of flax, and old linen also yield a very good charcoal. Remove the bark, leaves, and smaller branches, selecting branches 1 to 2 inches in thickness. These are cut into lengths of 5 or 6 feet, and tied in bundles, weighing about 30 lb. The wood will not be injured by exposure to the rain, as that tends to remove extractive matter. The carbonisation is effected either in pits, or in cast-iron cylinders. The yield of charcoal is 18 to 20 per cent., when prepared in pits; and 35 to 40 per cent. when prepared in cast-iron cylinders. The process of manufacture is similar to that adopted for ordinary charcoal, the pits or cylinders, however, replacing the ordinary kiln. If the charcoal is intended for sporting powder, it may be withdrawn whilst of a brown colour, when it is called "red charcoal." This would make a powder too explosive for war purposes. The latter is prepared from the black or distilled charcoal, which is more completely calcined, and is used by all English makers. The best quality has a bluish black colour, is light, firm, and slightly flexible, and should be used immediately it is made, as it rapidly deteriorates by keeping. Charcoal that has been too highly burned for war powder is used in the manufacture of blasting powder, as that need not be so inflammable.

Pulverising.—The required quantities of sulphur and charcoal are thoroughly pulverised, and intimately mixed, by being rolled for about four hours in a cast-iron drum, with numerous small brass balls, at a speed of about 28 revolutions a minute. When the mixture is complete, the powdered sulphur and charcoal are removed from the drum, and a proportionate quantity of saltpetre is added. Great care must be used in weighing out the various ingredients, according to the quality of the powder required, as upon that, and the complete mixing of the materials, the success of the manufacture depends.

Mixing.—The powder is put in a mixing machine, which is a leather drum, in which are placed numerous small bronze balls. The machine revolves at 25 to 30 revolutions a minute, and in about 4 hours' time the mixing is complete.

Granulating.—The powder having been damped and pressed into cakes, must then be crushed to the required size of grain. It is first roughly broken into lumps by small mallets; it is then fed into the granulating machine, which is caused to revolve for 35 or 40 minutes, at about 10 revolutions a minute. A small stream of water enters the granulator; the movement of the machine rolling the damp grains constantly among the dry meal powder causes the latter to adhere to their surface, and each grain is thus increased by concentric layers. When the small meal powder is all absorbed by the action of the granulator, the material is placed in a barrel ready for equalisation.

Equalising.—The grains as they come from the granulator are of various sizes; they are therefore sifted over two leather or parchment sieves, one of which is pierced to separate the grains which are too large, whilst the other allows all the dust to pass through, retaining only the grains which are of the desired size. The small refuse powder which has passed through the sieve is again placed in the granulator, and acted upon as before described.

Glazing.—The powder is placed in a cask or barrel, which revolves on its axis at about 40 revolutions a minute; by the friction of the grains against each other they become round, smooth, and polished, in which state the powder will bear the shaking and friction of carriage without injury, and is less likely to absorb moisture than when in rough and angular grains.

Drying.—The powder must not be too rapidly dried, a temperature commencing at about 66° F., and gradually increased to 130° or 140° F., is a safe one; the operation requires 3 to 4 hours, and is best performed in a room warmed by steam pipes or hot-air flues. The powder is then fit for use, and may be packed in sacks, to be afterwards placed in casks, or in double casks; sporting powder is usually packed in tin canisters.

A much more complete account is given in Spons' Encyclopædia.

IRON AND STEEL TEMPERING.

(iii. 289.)

Casehardening Iron.—Procure a quantity of old boots, burn these until they become charred, beat off the black and charred portion with a hammer, until sufficient powdered carbon is obtained; then place this powder with the articles to be operated upon in a sheet-iron box or a piece of wrought-iron gas-pipe sufficiently large, taking care that the articles are well covered and in the centre of the mass; lute the ends or top of the box with clay, and place the whole in a fire made of coke, keeping them there for an hour or more, taking care that the heat shall be equal (between dark-red and red); now plunge the contents into water. Should the articles require to be blue, such as the barrels or chambers of pistols, repolish them on an emery wheel, and put them into a sand bath or powdered charcoal, until the blue colour is attained, taking them out immediately this change takes place. The following are mixtures that will do instead of the burnt leather:—3 parts of prussiate of potash to 1 sal ammoniac; or 2 parts sal ammoniac, 2 bone-dust, 1 prussiate of potash. Bones, urine, and night-soil, are also used for this purpose. A simple method of case-hardening iron is to sprinkle powdered prussiate of potash over it at a red heat and plunge into water; bichromate of potash, with the pith of rams' horns, may be used with good results, instead of the prussiate.

Hardening Tools.—The following colours and temperatures are required:—Pale straw, 430° F., for lancets, &c.; dark yellow, 470° F., for razors, &c.; dark straw, 480° F., for penknives; clay yellow, 490° F., for chisels and shears; brown yellow, 500° F., for adzes and plane irons; very pale purple, 520° F., for table-knives; light purple, 530° F., for swords and watch-springs; dark purple, 550° F., for softer swords and watch-springs; dark blue, 570° F., for small fine saws; blue, 590° F., for large saws; pale blue, 610° F., for saws, the teeth of which are set with pliers; greenish blue, 630° F., for very soft temper. To obtain the proper temper lay the metal on a lump of iron heated to a sufficiently strong heat in the forge or other fire. The desired temper may be thus secured with the greatest facility and exactitude, as the clean bright metal shows the degrees of oxidation from the blue upwards most distinctly, which oxidation can be arrested at will. Cleanliness, or rather brightness of surface, is essential.

Malleable Iron.—2 oz. fluoric acid, 1 oz. nitric acid, 1 oz. saltpetre, to 10 lb. of metal. When the metal is melted, add the solution. It can be made in a crucible in a brass furnace. When you have cast off patterns, the castings want keeping at red heat for three or four days in iron boxes in a furnace.

Softening Cast-Iron.—(*a*) Heat the metal to a bright red, cool quickly in water, reheat, and then anneal by cooling slowly in ashes.

(*b*) Heat the metal to a red heat, let it lie a few minutes until nearly black, and then throw it into soapsuds.

(*c*) Place the castings, surrounded by saw-dust, in an iron box, close it up with clay to exclude the air, and subject it to a red heat for several hours. The castings must be cold before they are withdrawn.

Softening Files.—(*a*) Cover them with oil and hold them over the fire until the oil blazes; as soon as the flame runs all over the file, plunge it into water.

(*b*) Put them in a moderately hot oven for half an hour if large files; but if small the first plan is the best.

Tempering Cast Steel.—Dissolve a small quantity of sal ammoniac in water, make the metal red, drop it into the mixture for a second or two, and take it out, leaving enough heat in the metal to draw it back a bit. If left till cold, the steel will be a great deal too hard.

Tempering Mill Picks and Chisels.—(*a*) Heat the bill to a blood-red heat, and then hammer it till nearly cold; again heat it to a blood-red, and quench as quick as possible in 3 gallons of water, in which is dissolved 2 oz. of oil of vitriol, 2 oz. of soda, and ½ oz. of saltpetre; or, 2 oz. of sal ammoniac, 2 oz. spirit of nitre, 1 oz. oil of vitriol. The bill to remain in the liquor until it is cold.

(*b*) 1 oz. white arsenic, 1 oz. spirits of salts, 1 oz. sal ammoniac, dissolved in 4 gallons of spring water, and kept in a tube or iron phial for use. Heat the tool to a blood-red heat, then quench it in this mixture, draw it gently over the clean fire till the spittle flashes off it, then let it cool.

(*c*) To 3 gallons of water add 3 oz. o spirit of nitre, 3 oz. of spirits of hartshorn, 3 oz. of white vitriol, 3 oz. of sal ammoniac, 3 oz. of alum, 6 oz. of salt, with a double handful of hoof parings; the steel to be heated a dark cherry-red. Used to temper chisels for cutting French burr stones.

Tempering Springs. — Get a piece of spring steel about the size of spring wanted; when forged and filed to tilt, make it warm-red, immerse in spring water (a little cow-dung improves it, mixed well with the water before using it). Dry the spring, then tie a piece of wire fast to the spring in any form, so as to hold it. Dip in clean tallow or oil, put it on the fire till all the grease is burnt off, and swing round and round as swift as you can till cold.

IVORY.

Artificial.—Make isinglass and brandy into a paste, with powdered egg-shell, very finely ground. Give it any desired colour; oil the mould, into which the paste must be poured warm. Leave the paste in the mould until dry, when its appearance strongly resembles ivory.

Defective.—By holding the ivory up to the light, it will be seen whether there are any specks or holes in it; if any exist, they will be fatal to the success of the painting. It is often necessary to remove the defects found in the ivory in the state in which it is sold. To remove the marks of the saw, scrape the surface equally in every direction with an eraser, or an old razor with a fine edge, by which the marks of the saw are removed; then, with a piece of fine cork, or a roll of paper, dipped in finely pulverised and sifted pumice, or tripoli powder and water, rub the ivory with a circular motion in every direction, until the surface presents one uniform tint, but it must not appear polished; finish with a stump and a little cuttlefish powder carefully sifted; then, with a large camel-hair pencil and water, wash the surface of the ivory, and it will be ready to receive the colours. To render the ivory perfectly flat, place it between two pieces of white paper, and subject it to pressure by placing a weight upon it.

Flexible.—Immerse the ivory in a solution of pure phosphoric acid, sp. gr. 1·13, until it partially loses its opacity; then wash in cold soft water, and dry. This renders ivory very flexible, but it regains its hardness if long exposed to dry air. Its pliability may, however, be restored by immersion in hot water.

Mounting.—The ivory should be fastened at the four corners to a piece of cardboard, for the convenience of painting on; the back of the ivory should be kept perfectly clean, as any application of gum or glue to its surface destroys the transparent quality upon which its usefulness depends. After the surface to be painted on is properly cleaned, it should on no account be touched with the fingers, as the employment of ox-gall to remove greasiness must be scrupulously avoided. An ivory palette is best adapted for miniature painting, because the tints appear on it the same as when worked on the miniature, a matter of considerable importance.

Preparing for Miniature Painting.—

It is usual to paint miniatures upon ivory which is sold prepared for the purpose by the artists' colourman, after being subjected to a bleaching process by boiling, or exposure to the rays of the sun; but the bleaching can be more expeditiously performed by placing the ivory before a good fire, which will dispel the wavy lines, if they are not very strongly marked, that frequently destroy the requisite uniformity of surface. Ivory of the best quality has but few of these wavy lines, but it is frequently expedient to employ that of inferior quality. (See also ii. 33, 90, 124, 234, 358, 400.)

LATHING AND PLASTERING.

The plaster used for covering the walls of buildings is a mortar composed of lime or cement and sand, mixed in various proportions, generally with a little hair or some such material to give it elasticity. It is laid on by hand with a trowel in several thicknesses of about $\frac{1}{8}$ to $\frac{1}{4}$ inch each, and either on the bare masonry wall or on a special screen of lathing made for it, to either of which it adheres by entering into and keying itself in the joints and openings, and by its adhesive quality. With some variations in the materials and mixing, it is used for exterior and interior work and for ceilings. For the purpose of assisting to keep the interior of the rooms of a house dry, it is advantageous to employ lathing, which being detached from the masonry of the walls, forms a lining, distinct in itself, and not liable to the effect of moisture which may be in the walls. It is of the utmost importance, in plasterers' work, that the lime should be most thoroughly slaked, or the consequence will be blisters thrown out upon the work after it is finished. Many plasterers keep their stuffs a considerable period before they are wanted to be used in the building, by which the chance of blistering is much lessened. When a wall is to be plastered, it is called "rendering"; in other cases the first operation, as in ceilings, partitions, &c., is

Lathing, nailing the laths to the joists, quarters, or battens. If the laths are of oak, wrought-iron nails must be used for nailing them, but cast-iron nails may be employed if the laths are of fir. The lath is made in 3 or 4 foot lengths, and, according to its thickness, is called single, something less than $\frac{1}{4}$ inch thick, lath and half, or double. The first is the thinnest and cheapest, the second is about one-third thicker than the single lath, and the double lath is twice the thickness. When the plasterer laths ceilings, both lengths of laths should be used, by which, in nailing, he will have the opportunity of breaking the joints, which will not only help in improving the general key (or plastering insinuated behind the lath, which spreads there beyond the distance that the laths are apart), but will strengthen the ceiling generally. The thinnest laths may be used in partitions, because in a vertical position the strain of the plaster upon them is not so great; but for ceilings the strongest laths should be employed. In lathing, the ends of the laths should not be lapped upon each other where they terminate upon a quarter or batten, which is often done to save a row of nails and the trouble of cutting them, for such a practice leaves only $\frac{1}{4}$ inch for the thickness of the plaster; and if the laths are very crooked, which is frequently the case, sufficient space will not be left to straighten the plaster.

Laying. — After lathing, the next operation is laying, commonly called plastering. It is the first coat on laths, when the plaster has two coats or set work, and is not scratched with the scratcher, but the surface is roughed by sweeping it with a broom. On brickwork it is also the first coat, and is called rendering. The mere laying or rendering is the most economical sort of plastering, and does for inferior rooms or cottages. What is called pricking up is the first coat of three-coat work upon laths. The material used for it is

Coarse Stuff, being only the preparation for a more perfect kind of work.

Coarse stuff is made with chalk-lime prepared as for common mortar, but slaked with a quantity of water, afterwards evaporated, mixed with an equal quantity of clean sharp sand, and ox-hair at the rate of 1 lb. of hair to 3 cub. feet of stuff. After the coat is laid on, it is scored in diagonal directions with a scratcher (the end of a lath), to give it a key or tie for the coat that is to follow it.

Lath layed or *plastered and set* is only two-coat work, as mentioned under laying, the setting being the gauge or mixture of putty and plaster, or, in common work, of

Fine Stuff, with which, when very dry, a little sand is used. Fine stuff is a mortar made of fine white lime exceedingly well slaked with water, or rather formed into a paste in water to make the slaking complete: for some purposes a small quantity of hair is mixed up with it. Fine stuff very carefully prepared, and so completely macerated as to be held in solution in water, which is allowed to evaporate till it is of sufficient consistence for working, is called putty, plasterers' putty.

Setting may be either a second coat upon laying or rendering, or a third coat upon "floating," which will be hereafter described. The term "finishing" is applied to the third coat when of stucco, but "setting" for paper. The setting is spread with the smoothing trowel, which the workman uses with his right hand, while in his left he uses a large flat-formed brush of hog's bristles. As he lays on the putty or set with the trowel, he draws the brush, full of water, backwards and forwards over its surface, thus producing a tolerably fair face for the work.

Floating.—Work which consists of three coats is called floated: it takes its name from an instrument called a float, which is an implement or rule moved in every direction on the plaster while it is soft, for giving a perfectly plane surface to the second coat of work. Floats are of three sorts: the hand float, which is a short rule that a man by himself may use; the quirk float, which is used on or in angles; and the Derby, which is of such a length as to require two men to use it.

Plaster, float, and set is the term for three coats of plaster on laths. The first or pricking-up coat is of coarse stuff put on with a trowel to form a key behind the laths, and about $\frac{1}{4}$ or $\frac{3}{8}$ inch thick on the laths: while it is still moist it is scratched or scored all over with the end of a lath in parallel lines 3 or 4 inches apart, the scorings being made as deep as possible without exposing the laths; the rougher the edges are the better, as the object is to produce a good key for the next coat. When the pricking-up coat is sufficiently dry not to yield to pressure in the slightest degree, the second coat or floating is put on. The floating is of fine stuff with a little hair mixed with it; ledges or margins, 6 or 8 inches wide, and extending across the whole width of a ceiling or height of a wall, are made at the angles and at intervals of about 4 feet apart throughout: these must be made perfectly in one plane with each other with the help of straight-edges. These ledges are technically called "screeds." They form gauges for the rest of the work, and when they are a little set the spaces between them are filled up flush, for which a Derby float or a long straight-edge is used. The screeds on ceilings ought to be levelled, and those on the walls plumbed. When the floating is sufficiently set it is swept with a birch broom for the third coat or setting. The third, or setting coat, should be of plasterers' putty if the ceiling or wall is to be whitened or coloured. If it is to be papered, the third coat should be of fine stuff, with a little hair in it. If it is to be painted, the third coat should be of bastard stucco trowelled.

Bastard stucco is of three coats, the first is roughing in or rendering, the second is floating, as in trowelled stucco; but the finishing coat contains a small quantity of hair behind the sand. This work is not hand-floated, and the trowelling is done with less labour than what is termed trowelled stucco.

Trowelled stucco, which is the best sort of plastering for the reception of paint, is formed on a floated coat of work, and such floating should be as dry as possible before the stucco is applied. In the last process, the plasterer uses the hand float, which is made of a piece of half-inch deal, about 9 inches long and 3 inches wide, planed smooth, with its lower edges a little rounded off, and having a handle on the upper surface. The ground to be stuccoed being made as smooth as possible, the stucco is spread upon it to the extent of 4 or 5 feet square, and moistening it continually with a brush as he proceeds, the workman trowels its surface with the float, alternately sprinkling and rubbing the face of the stucco, till the whole is reduced to a fine even surface. Thus, by small portions at a time, he proceeds till the whole is completed. The water applied to it has the effect of hardening the face of the stucco, which, when finished, becomes as smooth as glass.

Ceilings are set in two different ways; that is the best wherein the setting coat is composed of plaster and putty, commonly called gauge. Common ceilings are formed with plaster without hair, as in the finishing coat for walls set for paper.

Pugging is plaster laid on boards, fitted in between the joists of the floor to prevent the passage of sound between two stories, and is executed with coarse stuff. In the country, for the interior coating of dwellings and outbuildings, a species of plastering is used called "roughcast." It is cheaper than stucco or Parker's cement, and therefore suitable to such purposes. In the process of executing it, the wall is first pricked up with a coat of lime and hair, on which, when tolerably well set, a second coat is laid of the same materials as the first, both as smooth as possible. As fast as the workman finishes this surface, another follows him with a pailful of the roughcast, with which he bespatters the new plastering, so that the whole dries together. The roughcast is a composition of small gravel, finely washed, to free it from all earthy particles, and mixed with pure lime and water in a state of semi-fluidity. It is thrown from the pail upon the wall, with a wooden float, about 5 or 6 inches long, and as many wide, formed of ½-inch deal, and fitted with a round deal handle. With this tool the plasterer throws on the roughcast with his right hand, while in his left he holds a common whitewashers' brush dipped in the roughcast, with which he brushes and colours the mortar and the roughcast already spread, to give them, when finished, a uniform colour and appearance.

MARBLE WORKING.

Marbles are generally cut up in the same direction in which they are quarried; this is known as sawing with the grain. Sometimes it is necessary to cut them against the grain, which renders them more difficult to work. Some marbles can only be sawn in the direction in which they are cut up. The marble worker is often obliged to rough hew and work without the help of the saw, casings, columns, and other articles with curved outlines; sometimes, but rarely, he re-works with the chisel badly-executed sawings; he then squares each piece with the saw or chisel to the required dimensions, and finally mounts the marble upon its stone core, and sets up the work in its place. The working of mouldings takes much time and trouble. The first operation is to saw the arris, then to work with a notched chisel making several successive groovings, on account of the contour and expansion, in which but very small pieces of the material are taken, for fear of splintering it; finish with small common chisels, which should be sharp and well tempered. Cylindrical pieces, such as round pedestals, columns, urns, and vases, are worked with a chisel, and then if portable, finished on a turning lathe. When it is impossible to place the pieces in a lathe, they are thickly grooved, bolstered with the puncheon, and the desired contours obtained by means of thick panels they are then worked with a small chisel, which removes the dust, and thus prepares the marble for polishing.

Polishing.—(*a*) Polishing includes five operations. Smoothing the roughness left by the burin is done by rubbing the marble with a piece of moist sandstone for mouldings. Either wooden or iron mullers are used, crushed and wet sandstone, or sand, more or less fine according to the degree of polish required, being thrown under them. The second process is continued rubbing with pieces of pottery without enamel, which have only been baked once, also wet. If a brilliant polish is desired, Gothland stone instead of pottery is used, and potters' clay or fullers' earth is placed beneath the muller. This operation is performed upon granites and porphyry with emery and a lead muller, the upper part of which is encrusted with the mixture until reduced by friction to clay or an impalpable powder. As the polish depends almost entirely on these two operations, care must be taken that they are performed with a regular and steady movement. When the marble has received the first polish, the flaws, cavities, and soft spots are sought out and filled with mastic of a suitable colour. This mastic is usually composed of a mixture of yellow wax, rosin, and Burgundy pitch, mixed with a little sulphur and plaster passed through a fine sieve, which gives it the consistency of a thick paste. To colour this paste to a tone analogous to the ground tints or natural cement of the material upon which it is placed, lampblack and rouge, with a little of the prevailing colour of the material, are added. For green or red marbles, this mastic is sometimes made of gum lac, mixed with Spanish sealing wax of the colour of the marble; it is applied hot with pincers, and these parts are polished with the rest. Sometimes crushed fragments of the marble worked are introduced into this cement; but for fine marbles, the same colours are employed which are used in painting, and which will produce the same tone as the ground; the gum lac is added to give it body and brilliancy. The third operation of polishing consists in rubbing it again with a hard pumice under which water is constantly poured unmixed with sand. For the fourth process, called softening the ground, lead filings are mixed with the emery mud produced by the polishing of mirrors or the working of precious stones, and the marble is rubbed with a compact linen cushion, well saturated with this mixture; rouge is also used for this polish. For some outside works, and for hearths and paving tiles, marble workers confine themselves to this polish. When the marbles have holes or grains, a lead muller is substituted for the linen cushion. In order to give a perfect brilliancy to the polish, the gloss is applied. Well wash the prepared surfaces, and leave them until perfectly dry; then take a linen cushion, moistened only with water, and a little powder of calcined tin of the first quality. After rubbing with this for some time, take another cushion of dry rags, rub with it lightly, brush away any foreign substance which might scratch the marble, and a perfect polish will be obtained. A little alum mixed with the water used penetrates the pores of the marble, and more speedily gives it a polish. This polish spots very easily, and is soon tarnished and destroyed by dampness. It is necessary, when purchasing articles of polished marble, to subject them to the test of water; if there is too much alum, the marble absorbs the water, and a whitish spot is left.

(*b*) If the piece to be polished is a plane surface, it is first rubbed by means of another piece of marble, or hard stone, with the intervention of two sorts of sand and water; first with the finest river or drift sand, and then with common house or white sand, which latter leaves the surface sufficiently smooth for its subjection to the process of gritting. Three sorts of grit stone are employed; first, Newcastle grit; second, a fine grit brought from the neighbourhood of Leeds; and lastly, a still finer, called snake grit, procured at Ayr, in Scotland. These are rubbed successively on the surface with water alone; by these means the surface is gradually reduced to that closeness of texture, fitting it for the process of glazing, which is performed by means of a wooden block having a thick piece of woollen stuff wound tightly round it; the interstices of the fibres of this are filled with prepared putty powder, or peroxide of tin, and moistened with water; this being laid on the marble and loaded, it is drawn up and down the marble by means of a handle, being occasionally wetted, until the desired gloss is produced. The polishing of mouldings is done with the same materials, but with rubbers varied in shape according to that of the moulding. The block is not used in this case; in its stead a piece of linen cloth, folded to make a handful; this also contains the putty and water. Sand rubbers employed to polish a slab of large dimensions should never exceed $\frac{2}{3}$ of its length, nor $\frac{1}{3}$ of its width; but if the piece of marble is small, it may be sanded itself on a larger piece of stone. The grit rubbers are never so large that they may not be easily held in one hand; the largest block is about 14 in. in length and $4\frac{1}{2}$ in breadth.

Mounting.—Marble workers mount and fasten their works upon plaster mixed with a third part of dust, as pure plaster repels the marble, and causes it to swell out and burst. These are joined together by cramps and gudgeons of iron and copper, which should be carefully covered, in order that the oxides may not spot the casings. Marble chimney-pieces should be lined with lias stone or plaster.

Selecting.—Examine each piece, note its beauties, and endeavour to hide its defects before cutting or working it. When fine pieces are found, endeavour to cut them into two or three parts, in order to multiply them, cutting them in such a manner that these happy accidents may be reproduced according to taste.

Veneering on Wood.—Veneering upon wood is preferable, in every respect, to that on stone. For this purpose, as marble, particularly the black, would break by heating it in the usual manner, place the slabs of marble in a caldron, tightly closed, in which let them boil. Then take them from the caldron, and after this preliminary operation, subject the marble to the heat of the fire to receive a mastic of tar. The wood having been prepared in a similar manner, press the marble, coated with the mastic, upon the wood, and a perfect cohesion is effected. The cases of ornamental clocks are hollow, for the movement of the pendulum and other works. This hollowing cannot be effected on stone without detriment to its solidity. When wood is used, a frame is made of it, upon the exterior parts of which marble is to be veneered. The mixture of glue with tar is found an improvement in effecting this veneering.

Veneering on Metals.—As these possess a smooth surface, the substance which should fasten them to the marble cannot incorporate itself with them intimately enough to join both and render them inseparable. It is therefore necessary to interpose between the metal and the marble a third body, which should force them to perfectly adhere; this is effected by the use of sand-paper.

Veneering on Zinc.—Take a plate of zinc of about $\frac{1}{10}$ inch thick; make a frame of this of the form of whatever article may be wished; upon this form glue sand-paper, leaving the rough side outermost, and upon this rough side apply the marble, having first prepared it by heating in a water bath, and placing between the marble and the sand-paper a coating of mastic of tar. By this means, so perfect an adhesion between the marble and the zinc is effected, that the marble could be more easily broken than removed. The application of marble upon zinc can also be effected by grooving the metal in every direction with strokes of the file, but the sand-paper produces the best results. Zinc is preferred to other metals, because it possesses resistance and cheapness, and causes no other expense in the manufacture than that of cutting up to form the model. Tin does not possess the same resistance or cheapness; sheet iron is dearer; cast iron is too heavy; copper is expensive; by the application of marble upon zinc, articles can be manufactured at the same price as those veneered upon wood. In fastening marble to the metallic plating, the tar which is used in the application of marble to stone will not be sufficient. The parts must first be heated in a water bath, or over a furnace prepared for this purpose, and then, by a sieve, sprinkled with one of the following mordants:—Crushed glass, grains of emery of all sizes, copper filings, castings of any metal, finely-rasped lead, or any kind of powdered stone, such as sandstone, marble, granite, or pumice, and rubber, can also be used. When the sheets of metal and of marble have received sufficient mordant, join with a coating of tar, which fastens them strongly together. Any web of linen or cotton can be placed between the marble and the metal; this web being covered with grainy substances, stuck on by glue.

Veneering on Boxes.—The marble is first sawn to thickness and form required for the dressing case or box to which it is to be applied. The wood, usually white wood, oak or fir, is cut a little smaller than the marble which is to cover it. This wood is lined with a shaving of beechwood, to prevent warping. This lining is only placed on the side which is to receive the marble; each piece of marble is then applied to the corresponding piece of wood, and stuck on by glue or other mastic. When the marble has been applied, the opposite side of the wood is thinly lined with rosewood or mahogany, so that this lining forms the inside of the box, which is thus prepared for receiving the necessary divisions. The four parts are then dovetailed together, and the top and bottom parts are fastened flatwise on the four sides with glue or mastic. The box being finished, the outside is pumiced and polished, and any applications of gilding can be made.

Sculpture of Marble by Acids.—Prepare a varnish by pulverising Spanish sealing wax, and dissolving it in spirits of wine. Trace on the white marble, with a crayon, the design which is to be formed in relief, and cover this delicately with a brush dipped in the varnish; in about 2 hours the varnish will be dry. Prepare a dissolvent of equal parts of spirits of wine, hydrochloric acid, and distilled vinegar; pour this solution upon the marble, and it will dissolve those parts which are not covered by the varnish. When the acid has ceased to ferment, and, consequently, will no longer dissolve the marble, pour on some fresh, which continue until the ground is sufficiently grooved. When there are delicate lines in the design which should not be grooved so deeply, they should at first be covered with varnish, to prevent the action of the acids upon them; then, when the reliefs have been made, the marble should be well washed, and the varnish removed from these delicate lines with the point of a pin; then pour on new acid, which will groove it as deeply as desired, care being taken to remove it at the proper time. When the acid has acted upon the marble, it corrodes beneath the varnish, and enlarges the lines in proportion to its depth; therefore draw the lines in relief a little larger than it is desired to leave them. When the work is completed, remove the varnish with spirits of wine, and, as the grounds will be very difficult to polish, they may be dotted with ordinary colours diluted with the varnish of gum lac. The marble being thus grooved, the cavities may be filled in inlaid work with gold, silver, tin, sealing wax, sulphur, or pearl shell reduced to powder. These designs can be made either in moulding or in relief, without changing or injuring the marble; every sort of writing, however delicate it may be, can also be thus traced; and the execution is very rapid, whether in groovings inlaid with gold or silver, or in relief, which can also be gilded or silvered.

Mastic for Repairs.—Mastic for stopping up holes, leakages, or cracks in marbles, is made with gum lac, coloured, as nearly as possible, to imitate the marble upon which it is used. Sometimes the gum is mixed with marble dust passed through a silken sieve; in other cases little pieces are used, which are cut and adjusted in the hole to be repaired, and glued there with the gum mastic—the precaution being first taken to heat the marble and the pieces, and to take measures for producing a perfect cohesion.

Cement Mastic.—(*a*) Thick mastic is composed of 2 parts wax, 3 of Burgundy pitch, and 8 of rosin; melt and throw into spring water to solidify the paste, then roll it into sticks, and, in using it, melt only so much as is immediately required; this will preserve its strength, as it becomes more brittle by repeated heating.

(*b*) Corbel mastic is used in seams of the flagging of stairways and terraces. Six parts of the cement of good Burgundy tile without any other mixture, pass it through a silken sieve, add 1 part of pure white-lead, and as much litharge, steep the whole in 3 parts of linseed oil and 1 of lard oil, and preserve in cakes or rolls as the preceding. All the materials used should be thoroughly dry, so that they may perfectly mix with the oil which unites them.

(*c*) Fountain mastic is made of the rubbish of stoneware or of Burgundy tile, amalgamated with thick mastic in such a manner as to form a paste proportioned to the use for which it is required; this is one of the easiest to prepare.

(*d*) Mastic of filings is employed in places which are usually damp, or which constantly receive water, as curb stones, flaggings of kitchens, bath-rooms and water-closets, and stone troughs composed of several pieces, either separate or clasped. This mastic is composed of 26½ lb. of iron filings, or of iron and copper, which must not be rusty, 4½ lb. of salt, and 4 garlics; this is infused for 24 hours in 3½ pints of good vinegar and urine; it is then poured off, and the thick paste which is found at the bottom of the vessel is the mastic, which should be immediately used.

These mastics should be used upon materials which are perfectly dry, otherwise they do not incorporate well. Choose dry weather, and open the seams well with a curved, sharp instrument, finally polishing them with the chisel. Before laying the mastic, remove the dust from the seam by blowing into it with bellows; a long, straight, iron chafing dish, closed at the bottom, with the grate elevated about an inch to obtain a current of air, is then passed over the seam; this chafing dish is filled with burning charcoal, the heat of which draws out the moisture from the stone or marble. The slightest dust or dampness hinder the adherence of mastic. (See also ii. 93.)

Cold Mastic.—Hydrochlorate of ammonia, 2 parts; flowers of sulphur, 1 part; iron filings, 16 parts. Reduce these substances to a powder, and preserve the mixture in closely-stopped vessels. When the cement is used, take 20 parts of very fine iron filings, add 1 part of the above powder, mix them together, adding sufficient water to form a manageable paste: this paste, which is used for cementing, solidifies in 15 days or 3 weeks, in such a manner as to become as hard as iron.

Masons' Mastic. — Pulverised baked bricks, quick-lime, wood ashes, equal parts. Mix thoroughly, and moisten with olive oil. This mastic hardens immediately in the air, and never cracks beneath the water.

STUCCOES.—Stucco is a composition of slaked lime, chalk, and pulverised white marble tempered in water, designed to imitate different marbles used in the interior of buildings or monuments. Calcined plaster of Paris is also used. Although the plaster becomes very hard when properly calcined, it is too porous to admit of polishing it as marble. To remedy this, the plaster is wetted with glue or gum water, which, filling the pores, allows a polish to be given it. Some mix the glue with isinglass or gum arabic. Hot glue water is used for the solution of the plaster, as the want of solidity of the plaster demands that a certain thickness should be given to the works; to lessen expense, the body or core of the work is made of common plaster, which is covered with the composition just described, giving it about an inch in thickness. When the work is dry, it is polished in nearly the same manner as real marble. Pumice may be used. The work is rubbed by the stone in one hand, the other holding a sponge filled with water, with which the spot which has just been rubbed is instantly cleansed, to remove what has been left on the surface of the work; the sponge should be frequently washed and kept filled with fresh water. The marble is then rubbed with a linen cushion, with water and chalk or tripoli stone. Willow charcoal, finely pulverised and sifted, is substituted for this to penetrate better to the bottom of the mouldings, water being always used with the sponge, which absorbs it. The work is finished by rubbing it with a piece of felt soaked with oil, and finely powdered with tripoli stone and afterwards with the felt moistened with the oil alone. When a colour is wished in the ground, add it to glue water, before making use of it to temper the plaster. When any particular marble is to be imitated, dilute with warm glue water, in different small pots, the colours of which are found in the marble; with each of these colours temper a little plaster, then make of each a lump nearly as large as the hand, place these lumps alternately one above another, making those of the prevailing colour more numerous, or thicker. Turn these lumps upon the side, and cut them in slices in this direction, instantly spreading them upon the core of the work, or upon a flat surface. By this means the design of the various colours with which the marble is penetrated will be represented. In all these operations the glue water should be warm, without which the plaster will set too quickly, without giving time to work.

Wax Varnish to Preserve Statues and Marble exposed to the Air. — Melt 2 parts of wax in 8 parts of pure essence of turpentine. Apply hot, and spread thinly, so as not to destroy the lines of the figures. This varnish may be used upon statues which have been cleansed with water dashed with hydrochloric acid, but they must be perfectly dry when the application is made.

Colouring Marble in Imitation of Mosaic Work.—*Colours.*—Solution of nitrate of silver penetrates marble deeply, communicating to it a deep red colour. Solution of nitro-muriate of gold produces a very fine violet colour. Solution of verdigris penetrates marble $\frac{1}{12}$ inch, giving a fine light green colour. Solutions of gum dragon and of gamboge also penetrate it; the first produces a fine red, and the second a yellow colour. To cause these two substances to penetrate deeply, the marble should first be well polished with pumice, after which the substances should be dissolved in warm alcohol, and applied with a small brush. All the wood dyes made with alcohol penetrate marble deeply. Tincture of cochineal, prepared in this manner, with the addition of a little alum, gives a fine scarlet colour to the marble, penetrating it $\frac{1}{5}$ inch. Artificial orpiment, dissolved in ammonia and laid on marble with a brush, quickly produces a yellow colour, which becomes more brilliant when exposed to the air. To all the substances employed, add white wax; this, when placed on the marble in a melted state, soon penetrates it. If the verdigris is boiled in wax, and then laid melted upon the marble, it will be seen on its removal, when cold, that the design has penetrated the surface to the depth of $\frac{1}{3}$ to $\frac{1}{2}$ inch.

Application.—When several colours are to be successively used without blending them, proceed in the following manner. The dyes obtained by spirits of wine and the oil of turpentine should be laid on the marble when it is heated, particularly in the execution of delicate designs, but the dragon's-blood and gamboge may be used cold. For this they must be dissolved in alcohol, and the gamboge used first; the solution of this gum is quite clear, but soon becomes troubled and gives a yellow precipitate, which is used to obtain a brighter colour. The lines drawn by this solution are then heated by passing a chafing dish filled with lighted charcoal closely over the surface of the marble. It is then left to cool, after which the lines which have not been penetrated by the colour are heated in the same manner. When the yellow colouring has been applied, the solution of dragon's-blood, which should be concentrated as much as possible, is employed in the same manner as the gamboge; and while the marble is warm, the other vegetable tints which do not require so strong a degree of heat, may also be applied. The design is completed by the colours mixed with wax, which should be applied with the utmost care, as the slightest excess of heat will cause them to spread, for which reason they are less suited to delicate designs. In colouring marble, the pieces should be well polished, and free from any spots or veins. The harder the marble, the better it supports the heat necessary to the operation; alabaster and common soft white marble are not suitable for the purpose. Marble should never be heated to a red heat, as the fire then alters the texture, burns the colours, and destroys their beauty. Too slight a degree of heat is also bad; for though the marble takes the colour, it does not retain it well, and is not penetrated deeply enough. There are some colours which it will take when cold, but these never fix so well as when heat is employed. The proper heat is that which, without reddening the marble, is intense enough to cause the liquor which is on its surface to boil. The menstrua which are used to incorporate the colours should be varied according to the nature of the colour employed; a mixture made with urine mixed with 4 parts of quick-lime and 1 of potash, is excellent for certain colours, common lye of wood ashes is good for others; for some, spirits of wine, others require oily liquors, or common white wine. The colours which succeed best with the different menstrua are the following; blue-stone dissolved in six times its quantity of spirits of wine or urine, and litmus dissolved in a lye of pearlash; the extract of saffron and sap green succeed very well when dissolved in urine or quick-lime, and tolerably in spirits of wine. Vermilion and cochineal dissolve well in the same liquids. For dragon's-blood use spirits of wine, which is also used for Campeachy wood. For alkanet-root the only menstruum is turpentine. Dragon's-blood in tears gives a beautiful colour when mixed with urine alone. Besides these mixtures, certain colours can be put on dry and unmixed; such as the purest dragon's-blood for the red, gamboge for the yellow, green wax for a kind of green, common sulphur, pitch, and turpentine, for a brown colour. For all these the marble must be considerably heated, and the dry colours then rubbed upon the block. A beautiful golden colour is produced by equal quantities of the crude salts of ammonia, of vitriol, and of verdigris, the white vitriol is the best for this purpose. Grind these together, and reduce them all to a very fine powder. All the shades of red and yellow may be given to the marble with the solutions of dragon's-blood and gamboge, by reducing these gums to powder and grinding them with spirits of wine in a glass mortar. When only a little is required, mix one of these powders with spirits of wine in a silver spoon, and hold it over a heated brazier; this extracts a fine colour, and, by dipping a small brush in it, the finest veins may be made upon the cold marble. By adding a little pitch to the colouring, a black shade, or all the varieties of dark red, can be given. Archil diluted in water and applied when cold to the marble gives it a beautiful blue colour; by putting on the colouring in proportion as it dries, it becomes very fine in less than 24 hours, and penetrates deeply. If the paste of archil is used, which is a preparation of the plant with lime and fermented urine, the colour obtained will be more of a violet than blue; to obtain a perfect blue it must be diluted in lemon juice; this acid will not injure the marble, as it has been weakened by its action upon the archil. Large blue veins may thus be formed upon white marble; but as this colour is apt to spread, it will not be exact unless the coloured parts are instantly touched with dragon's blood, wax, or gamboge, which checks it.

CLEANSING MARBLE. — Scraping

marble which has been blackened or turned green by air and damp is dangerous to the design; whatever precautious may be taken, the work is always scratched more or less, and it is impossible to clean the carved parts without breaking the sculpture, or causing incongruities between the designs in relief and those which are sculptured. Soiled articles, which have not been tarnished by exposure to the open air, may be cleansed by potash water, then wash them in pure water, finish with water containing a dash of hydrochloric acid. Soap and water is often sufficient, spread on with a brush, and introduced into the sculptured parts by a somewhat stiff pencil.

To Remove Stains from Marble.—(*a*) Take two parts of soda, one of pumice, and one of finely powdered chalk. Sift these through a fine sieve, and mix them into a paste with water. Rub this well all over the marble, and the stains will be removed; then wash it with soap and water, and a beautiful bright polish will be produced.

(*b*) Clean with dilute muriatic acid, or warm soap and vinegar; afterwards heat a gallon of water, in which dissolve 1½ lb. of potash; add 1 lb. of virgin wax, boiling the whole for half an hour, then allow it to cool, when the wax will float on the surface. Put the wax into a mortar and triturate it with a marble pestle, adding soft water to it until it forms a soft paste, which, laid on marble, and rubbed, when dry, with a woollen rag, gives a good polish.

Restoring the Colour of Marble.—Mix up a quantity of the strongest soap lees with quick-lime to the consistence of milk, and lay it on for 24 hours; clean it afterwards with soap and water. (See also ii. 125.)

REPAIRING MARBLE.—Heat the edges of the marble before a strong, clear, charcoal fire, avoiding dust or smoke, until the marble is sufficiently hot to take small pieces of shellac. Then choose a sufficient number of thin pieces, of such a size as not to project above the surface of the marble, and apply them along the edge of each piece to be joined; but in such a manner, that the bits of lac on each piece of marble will come between those on the other. Then just before applying them together, a hot iron must be passed along each piece at a sufficient distance to fuse the lac, but not to make it run. The pieces of marble must be well forced together.

MARBLE CEMENT.—Plaster of Paris soaked in a saturated solution of alum, baked in an oven, ground to powder. Mix with water.

Enamelling Slate.—The slate having been reduced to a perfectly level surface, a coating of colour is applied according to the stone it is intended to imitate. For black, tar varnish is used with good effect. The slab is then thoroughly baked in an oven heated at 130° to 250° F., for 12 to 48 hours, according to size. The colours, say grey and white, are then floated on to the surface of a cistern of water, over which they float naturally into the shapes of the streaks of colour seen in marble. The slate, with its black ground now burnt in, is dipped into the surface of the water, and receives from it a thin coat of colour. The slate again has to go into the oven, and when sufficiently hardened, a coating of enamel is applied. Another baking to harden the enamel, and the slab is then pumiced to reduce it to a level surface. Baked again, it is once more pumiced, and this time goes into the oven with the pumice wet on its surface. If necessary this last operation is repeated. The slab is then ready for polishing, which is effected firstly by woollen cloths and fine sand, next by the finest and softest French merino, and lastly, by the hand and powdered rotten-stone. The dipping process is not applicable to imitations of all stones. Some granites are best imitated by splashing; others by splashing and sponging combined, while some have to be hand-grained.

Mother-of-Pearl.

Mother-of-pearl is the inner coat of several kinds of oyster shells, some of which secrete this layer of sufficient thickness to render the shell an object of manufacture. The beautiful tints of the layer depend upon its structure, the surface being covered with a multitude of minute grooves, which decompose and reflect the light. The structure of the pearl shell admits of its being split into laminæ, and it can then be used for the handles of knives, for inlaying, or in the manufacture of buttons; but as splitting is liable to injure or spoil the shell, this method of dividing it is seldom resorted to. In manufacture the different parts are selected of a thickness as nearly as possible to suit the required purpose; excess of thickness is got rid of by means of saws, filing, or by grinding upon the common grindstone. In preparing the rough shell, if square or angular pieces are needed, they are cut with saws, as the circular saw or the ordinary back saw; in the one case, the shell is fed up as the saw divides it, and in the other the shell is held in a vice, and the saw operated by hand. If circular pieces of the shell are wanted, such as those for buttons, they are cut with an annular or crown saw, which is fixed upon a mandrel. It is necessary in sawing that water is plentifully supplied to the instrument, or the heat generated by dividing the shell will heat the saw, and its temper will be destroyed. The pieces of shell are next ground flat upon a grindstone, the edge of which is turned with a number of grooves or ridges, as being less liable to become clogged than the entire service, and hence grind more quickly. It is necessary to supply water, or soap and water, to the stone, as it is then less liable to become clogged. The flat side of the stone, similarly prepared with ridges, may be used instead of the face, if it is desired to have the pieces of shell ground flat, and when of the requisite thinness they are ready for operation in the lathe, or for inlaying.

After the pieces of pearl shell are cut, ground, or turned to the proper form, they are finished with pumice and water; this may be done with pieces of the stone properly shaped, and rubbed over the work as it is held fast in some form of clamp, or held upon the work as it is revolved in the lathe. This process may be followed by an application of ground pumice, which has been carefully sifted to extract all except the minutely powdered portion, and applied with a piece of cork or a cloth moistened with water. The polishing is accomplished with rotten-stone, moistened with dilute sulphuric acid, which may be applied upon a piece of cork or a bit of soft wood. In some turned works fine emery paper may be used, and followed with rotten-stone moistened with the acid or oil. The pearl handles used for razors or knives are first roughed out, then drilled where the rivets are to be inserted, and lightly riveted together in pairs. They are ground to the proper size and thickness, and finished by the means mentioned, the last finishing touch, to produce a fine polish, often being done by the friction of the hand of the workman. Sometimes it is advantageous to apply the polishing material to the surface of a wheel, and this wheel may be covered with cloth and moistened with water, which will cause enough of the powder to adhere. Separate wheels may be used for the pumice and rotten-stone. Sometimes dry powdered chalk or Spanish whiting is used in place of the rotten-stone.

One process of working pearl is by the aid of corrosive acids and the etching point. The shell is first divided as may be necessary, and the designs or patterns are drawn upon it with an opaque varnish; strong nitric acid is then brushed over the plates repeatedly, until the parts undefended by the varnish are sufficiently corroded or eaten away by the acid. The varnish now being washed off, the device, which the acid had not touched, is found to be nicely executed. If the design is to be after the manner of common etching on copper, the process upon the shell is precisely the same as that process upon metal. When a considerable number of pieces of thin shell are required to be of the same size and pattern, the requisite number of plates are cemented together with glue, and the device or figure is drawn upon the outer plate. They may then be held in a vice or clamp, and cut out as one plate with a fine saw, or wrought into the desired form with files; drilling tools may be employed to assist in the operation. To separate the pieces, the cemented shells are thrown into warm water, which softens the glue and separates the pieces.

Artificial Mother-of-Pearl Buttons.—White horn buttons may be made to imitate mother-of-pearl by being boiled in a saturated solution of sugar of lead, and then laid in very dilute hydrochloric acid. Combs, to which the boiling process is not applicable, as it distorts the teeth, may be treated by being kept over-night in a moderately concentrated cold solution of nitrate of lead, then laid for ¼ hour in a bath containing 3 per cent. of nitric acid, finally being rinsed in water. The use of sugar of lead is, however, prejudicial, and should be avoided.

Inlaying with Mother-of-Pearl.—(*a*) Tortoiseshell is softened by soaking it in hot water—the design arranged, and placed between flat dies, under a heavy press, to remain till the shell is cold and dry. It is thus embedded in the shell. Those vivid colours on paper trays are fragments of the Aurora shell, pressed in the same way, while the paper is damp; when dry, the design is painted, varnished, baked, and polished.

(*b*) Thin scales of the shell are selected for their colour or shade, and cemented to the surface of the material. The rest of the surface is covered with successive coats of japan varnish, generally black, being subjected to a baking process after each application. When the varnish is as thick as the shell, it is polished, the gilding and painting are added, and a flowing coat of varnish is put over the whole.

Imitating Tortoiseshell with Horn.—(*a*) Mix up an equal quantity of quick lime and red lead with soap lees; lay it on the horn with a small brush, in imitation of the mottle of tortoiseshell; when it is dry, repeat it two or three times.

(*b*) Grind 1 oz. of litharge and ½ oz. of quick lime, together with a sufficient quantity of liquid salts of tartar to make it of the consistence of paint. Put it on the horn with a brush, in imitation of tortoiseshell, and in three or four hours it will have produced the desired effect; it may then be washed off with clean water; if not deep enough it may be repeated.

(*c*) Take a piece of lunar caustic about the size of a pea; grind it with water on a stone, and mix with it a sufficient portion of gum arabic to make it of a proper consistence; then apply it with a brush to the horn in imitation of the veins of tortoiseshell. A little red lead, or some other powder mixed with it, to give it a body, is of advantage. It will then stain the horn quite through, without hurting its texture and quality. In this case, however, be careful, when the horn is sufficiently stained, to let it be soaked for some hours in plain water, previous to finishing and polishing it. Pieces of horn are united together to form one large piece by being softened at the edge by boiling water, and then pressing them together powerfully while surrounded by boiling water.

NITRO-GLYCERINE.

Nitro-glycerine is made in the following manner:—Fuming nitric acid (sp. gr. about 1·52) is mixed with twice its weight of the strongest sulphuric acid, in a vessel kept cool by being surrounded with cold water. When this acid mixture is properly cooled, there is slowly poured into it rather more than $\frac{1}{6}$ of its weight of glycerine; constant stirring is kept up during the addition of the glycerine, and the vessel containing the mixture is maintained at as low a temperature as possible by means of a surrounding of cold water, ice, or some freezing mixture. It is necessary to avoid any sensible heating of the mixture, otherwise the glycerine would be, to a considerable extent, transformed into oxalic acid. When the action ceases, nitro-glycerine is produced. It forms on the surface as an oily-looking fluid, the undecomposed sulphuric acid forming the subjacent layer, owing to its greater specific gravity. The whole mixture is then poured, with constant stirring, into a large quantity of cold water, when the relative specific gravities become so altered that the nitro-glycerine subsides and the diluted acid rises to the surface. After the separation in this manner into two layers is effected, the upper layer may be removed by the process of decantation or by means of a siphon, and the remaining nitro-glycerine is washed and re-washed with fresh water till not a trace of acid reaction is indicated by blue litmus paper. The final purifying process is to crystallise the nitro-glycerine from its solution in wood naphtha. The final process is not necessary when the compound is to be used at once.

As prepared in this manner, nitro-glycerine is an oily-looking fluid, of a faint yellow colour, perfectly inodorous, and possessed of a sweet, aromatic, and somewhat piquant taste. It is poisonous, small doses of it producing headache, which may also be produced if the substance is absorbed into the blood through the skin, and hence it is not desirable to allow it to remain long in contact with the skin, but rather to wash it off as soon as possible with soap and water. Glycerine has a specific gravity of 1·25–1·26, but the nitro-glycerine has a specific gravity of almost 1·6, so that it is a heavy liquid. It is practically insoluble in water, but it readily dissolves in ether, in ordinary vinic alcohol, and in methylic alcohol or wood spirit. If it is simply exposed to contact with fire, it does not explode: although it is so powerful as an explosive. A burning match may be introduced into it without producing any explosion; the match may be made to ignite the liquid, but combustion will cease as soon as the match ceases to burn. Nitro-glycerine may even be burned by means of a cotton wick or a strip of bibulous paper, as oil from a lamp, and as harmlessly. It remains fixed and perfectly unchanged at 212° F.; if heated to about 360° F., however, it explodes. It detonates when struck by the blow of a hammer, but only the part struck by the hammer explodes; the surrounding liquid remains unchanged.

As the carriage of nitro-glycerine is dangerous, many trials have been made to render it inexplosive, and to restore its explosiveness with equal readiness. Nobel's method of making it inexplosive is at once simple and effective. It is to mix with it from 5 to 10 per cent. of wood spirit, when all attempts at exploding it are rendered utterly futile. Five per cent. of methyl-alcohol is said to be amply sufficient to transform the nitro-glycerine into the inexplosive or protected state, but 10 per cent. is generally added before sending any liquid into the market. The transformation of protected into ordinary nitro-glycerine is effected by thoroughly agitating it with water, and allowing the mixture to settle for a short time. By this means the water dissolves out the methyl-alcohol, and the mixture of spirit and water readily rises to the surface, in virtue of its low specific gravity, and can be removed by means of a siphon, or by simply pouring it off. As a blasting liquid, it is now ready for use. If protected blasting liquid be kept in a closed vessel, it will remain in that state for an indefinite period of time, and ready at any moment to be reduced or rendered fit for action; if, however, it be exposed in an open vessel, it will regain its explosiveness, in periods of time proportionate to the amount or degree of exposure. For blasting purposes, the chief advantage which nitro-glycerine possesses is that it requires a much smaller hole or chamber than gunpowder does, the strength of the latter being scarcely $\frac{1}{10}$ that of the former. A chamber, 34 millimètres in diameter, was made perpendicularly in a dolomitic rock, 60 ft. in length, and at a distance of 14 ft. from its extremity, which was nearly vertical. At a depth of 8 ft., a vault filled with clay was found, in consequence of which the bottom of the hole was tamped, leaving a depth of 7 ft. One litre and a half of nitro-glycerine was then poured in; it occupied 5 ft. A match and stopper were then applied as stated, and the mine was sprung. The effect was so enormous as to produce a fissure 50 ft. in length, and another of 20 ft. Nitro-glycerine has, however, one disadvantage. It freezes at a temperature very probably above 92° F., and it is said that even at a temperature of 43° to 46° F. the oil solidifies to an icy mass, which mere friction will cause to explode. It is probable, however, that the freezing point of the oil lies somewhat lower than is here stated, though as yet no exact determination of the freezing point of the oil has been made. Great care must be exercised whilst it is in a frozen state, as otherwise it will cause most dreadful accidents.

Dynamite is made by mixing 75 per cent. of nitro-glycerine with 25 per cent. of powdered sand. Dynamite retains all the properties of nitro-glycerine for blasting, but is not so dangerous, as it may be handled freely. Explosion is produced by means of a percussion cap in the same manner as with nitro-glycerine.

PAINTING.

(ii. 436.)

Fresco.—The preparation of a wall for fresco painting is a matter of time, and should proceed with much carefulness, for on the goodness of this portion of the work depends in a great measure the durability of the painting. If the wall is already covered with plaster or laths, it should be cleared, the bricks thoroughly scraped, and afterwards well chipped. See that the bricks are in good condition and perfectly dry, and then proceed to lay on the first coat, consisting of river sand and the best old lime, mixed to about the usual thickness. This should be laid on so as to leave a level but rough surface. At some places on the Continent small flint pebbles are mixed with this composition to give the requisite roughness. This ground-work should be allowed to dry thoroughly; indeed, unless the lime is old, it will be some considerable time before it will be safe to put on the intonaco or painting-surface. This should be prepared with the very best old lime, perfectly free from grit. The lime is mixed in troughs to the consistence of milk, and is then passed through hair sieves into jars, where it is allowed to settle, and the water is poured off. It is then ready to be mixed with the sand (fine quartz sand, well sifted, is the best) in the proportion of one part lime to two parts sand. The implements used to float on the last coat are made of wood or glass, but trowels of iron may be used if free from rust, and care is taken not to press the iron too forcibly on the intonaco. When the lime and sand coating is ready to be laid, the rough cast must be wetted thoroughly, and the intonaco floated on in two coats, the last with rather more sand than the first. The thickness of the two should be about $\frac{3}{16}$ inch. After these are spread, go over the whole with a roll of wet linen, which will remove the marks of the trowel, and prevent the surface being too smooth. While the ground is being prepared, a cartoon or drawing on paper is made of the subject, executed with a correct outline and with the wished-for effect properly shown. When the finished cartoon is made the same size as the painting, it is usually executed in black and white with ink or crayons, but it is also necessary to have a study of the subject in colours, and this is generally done on a small scale. The pigments used are mostly minerals, and are ground and applied with pure water. With the surface of the wall still wet but firm and smooth, the tracing is laid over the portion prepared, and the lines of the cartoon are slightly indented on the plaster with a blunt point; or the lines have small holes in them pierced at certain intervals, and the design thus pricked out is laid upon the ground and dusted with a pounce-bag containing fine dry powder, and thus the outline is repeated on the ground by the dots of powder which have passed through the minute holes. When the intonaco has become firm enough to just bear the pressure of the finger, the first washes of colour may be put on. If the painting is intended to be large, only sufficient plaster is put on to serve for the part which can be accomplished in the time at the disposal of the painter, usually enough only for a day's work, and this portion should end at the edges of some bold outline, as flowing drapery, a pillar, and so on. A difficulty in fresco painting is that the colours become much lighter after the plaster dries, and for this allowance must be made; however by practice the painter may overcome this difficulty, and can test the difference between the colour as wet and as dry by putting a touch upon a piece of umber, which instantly dries the colour and shows it as it will be when the intonaco has dried.

Glass.—The different compounds for painting glass are glasses of easy fusion, chiefly coloured with ground metallic oxides, laid on the glass with spirits of turpentine. In the production and modification of glass colours, much depends on the different preparations of the metals, on the small proportion of the metallic oxides employed in proportion to the vitreous mass, on the degree of fire and time of its continuance, and on the purity of each ingredient intended for vitreous mixtures; from hence difficulties arise which even a skilful operator cannot always remove, and which often frustrate his intention. Having made choice of the subject to be painted, correctly draw the same on a paper exactly the size intended to be on the glass, then place the different pieces in regular order on the drawing, and trace the outlines therefrom on the glass; when the tracing is quite dry, the ground colours may be washed in, together with the dark and prominent shades, and the stains required. The stains are laid on in various thicknesses, according to the depth of colour required, and when they are dry the glass is ready to be burned in a muffle or kiln constructed for the purpose. The panes of glass are laid on sheets of iron, or earthenware bats, the size of the glass, previously spread over with dried ground flint, to prevent the surface of the glass from being defaced. After the first burning, the stain is washed off with warm water, which will bring to view every part of the subject, in fact, every shade according to the thickness of colour applied; to heighten the colour, paint on each side of the glass, and burn it a second time. The glass will require four to six firings, the exact number of firings depending on the subject, the degree of perfection required, and the manner of execution; but after each burning, the pieces of glass will want less labour, some of the colours and stains being perfect at the first and second burning, and few require the utmost quantity. The proper degree of heat to which the glass must be exposed in the muffle is ascertained by taking out at different intervals small pieces of glass, arranged for the purpose, on which are laid similar colours to those being fired. After the glass is burned, it requires great precaution in cooling, for if suddenly cooled it is apt to fly, consequently all sudden changes of temperature should be avoided.

Red, Orange, and Yellow Stains.—12 parts calcined green vitriol, 1 oxide of silver. The vitriol must be calcined to a reddish colour, and repeatedly washed with boiling water until it is completely freed from acid, which will be known by the water being insipid to the taste; then triturate the silver and vitriol together in a mortar, after which grind them up with spirits of tar for use. Various temperatures in burning produce various coloured stains, the highest a red, a less an orange, and so on to a yellow; but to procure a very deep red, the colour must be laid upon both sides of the glass.

White Enamel.—3 parts calcined borax, 2 flint, 1 oxide of tin, 1 Cornish stone. The basis of this enamel, which is in general opaque, may also be employed in assimilating the opaque natural stones. These ingredients must be well mixed up together, and fused in an air furnace in a crucible, the fire at first applied very gradually, and the whole repeatedly stirred with an iron rod. The mixture by this calcination, and by being kept for some time in fusion in an intense heat, acquires its fusibility and opacity.

Purple.—(*a*) 20 parts prepared purple, 2½ enamel flux (2), 1 white enamel.

(*b*) 20 parts prepared purple, 10 blue, 5½ enamel flux (2), 1 white enamel.

Rose Colour.— 20 parts prepared rose colour, 1 white enamel. The purples and rose colours for glass painting are nearly the same mixtures as those used for porcelain painting, with the addition of a small proportion of flux and white enamel. The latter gives firmness to the colour. In the course of working the rose colour, if a very small quantity of purple be added, the colour will be perceptibly benefited.

Red. — 1 part terra de sienna, 3 enamel flux (2). The terra de sienna must be calcined over a slow fire until its colour becomes of a dark red, after which it is washed several times in boiling water and ground with the flux for use.

Transparent Orange.—1 part oxide of silver, 10 enamel flux (2), 10 enamel flux (3), 1 white enamel.

Yellow.—1 part yellow under glaze, 3 enamel flux (2), ½ white enamel.

Dark Brown.—1 part highly calcined copperas, 3½ enamel flux (3).

Red Brown.—1 part black, 1 red, 1 enamel flux (4).

Light Brown.—1 part easy calcined umber, 3½ enamel flux (2).

Green.—(*a*) 5 parts cornelian red, 1 prepared purple.

(*b*) 2 parts blue, 1 yellow.

Blue.—(*a*) 8 parts flint glass, 3 red-lead, 1 potash, 1 blue calx, ½ common salt.

(*b*) 4 parts borax, 4½ flint glass, 1 flint, ½ potash, ½ prepared purple, 1 blue calx.

In preparing these blues, let the materials be calcined in an air furnace, and the whole mass kept in a state of fusion for some time, a fine blue glass enamel will be produced. The cobalt blue calx should be of the finest quality that possibly can be procured, and free from all impurities.

Black.—(*a*) 1 part highly calcined umber, 2 calcined borax, 1 red lead, 1 blue calx.

(*b*) 1 part manganese, 1 black flux.

The best Turkey umber should be procured for the first process, and calcined at the most intense heat that can be produced in an air furnace, after which pound and mix up with the other materials; then calcine the whole together in an air furnace. The degree of heat will be sufficient when the whole mass is in fusion.

Indigo Blue.—1 part precipitate of gold, 4½ enamel flux (4), ⅙ white enamel. These ingredients are simply ground together for use. They produce a beautiful colour on glass, of a fine purple hue. This very expensive colour is adapted principally for painting the draperies of figures, and is very susceptible of being injured by a high degree of heat.

Etching and Deadening Colour.—(*a*) 7 parts red lead, 2 calcined borax, 2 flint, 1 oxide of tin.

(*b*) 8 parts red-lead, 6 flint glass, 3 flint, ½ green copperas.

The materials of the last two processes must be finely mixed and calcined in an air furnace, each process separately, after which take 2 parts of (*a*) and 3 parts of (*b*), mix them together, and repeat the calcination again in an air furnace; then pound and grind this frit for use, but be particular that it is ground very fine, for much depends on the particles being minutely mixed previous to using. The composition is afterwards laid on the glass with water, and a small quantity of refined sugar dissolved in spring water is applied occasionally; the solution of sugar must be of the consistence of thick oil; should too large a quantity of the solution be added, and by that means condensate it too much, add a few drops of acetous acid to the menstruum; it will immediately regain a proper consistence, and not at all injure the colour. When the deadening is laid on the glass, the figures must be engraved or etched with a pointed instrument made of wood, bone, or ivory, suitable to the subject, and afterwards burnt in a kiln or muffle appropriated for the purpose. It fires at a less temperature than stained glass, although in some instances it will do in the same kiln. (See also iii. 228.)

Oil Colours.—The implements and materials necessary for oil painting are oil, varnish, colours, brushes, palette, palette knife, easel, rest stick, canvas, and a little chalk or crayon.

Palettes.—Palettes are made of mahogany, and of satin and other light-coloured woods also; those made of the latter are preferable, because the colours and mixed tints are best seen upon them. They should be light in weight, and thin, and so perforated as to rest well-balanced on the thumb. Palettes are made of oval and oblong shapes; the latter form is more generally useful and convenient, as affording a greater space for the working of tints, as well as for their advantageous arrangement. Wooden palettes should be prepared for use by rubbing into them as much raw linseed oil as they can be made to imbibe. If this dressing with oil be thoroughly effected, and the palette be then suffered to dry till it becomes hard, the wood will subsequently not be stained by the absorption of colour. A palette thus prepared is easily cleaned, and presents a hard and polished surface, exceedingly agreeable for the preparation of tints. It is important to keep the palette free from indentations and scratches, and on no account to neglect cleaning it; the colour never being allowed to harden upon the wood.

Easel.—The easel is a frame which supports the painting during its progress. Easels are of various forms; but the most convenient is undoubtedly the rack-easel, which allows the painter to raise or lower his work with speed and convenience, as occasion may require. The commoner and cheaper kinds are supplied with pegs for this adjustment of the height of the work. It is desirable that the easel should stand firmly, and not be liable, as is too often the case, to be overset by any slight cause.

Rest, or *Mahl Stick.*—This is used to rest or guide the right hand or arm when particular steadiness is required, as is the case in the painting of small objects and minute details. It is usually formed of cane or of lance-wood, and it should be light, yet firm. The lower end of the stick is held in the left hand, while the upper extremity, which is covered with a soft round ball or pad of leather, to prevent injury, rests on the canvas or some other convenient support.

Brushes.—To paint with effect, it is of the first consequence to have the brushes well selected, and of the best quality that can be procured. They are of various kinds:—of hog-hair, sable, badger, fitch, and goat-hair. Of these, the most useful are the hog-hair, sable, and badger brushes. The black fitch and white goat-hair are but seldom used, as the sable and hog tool will effect all that can be done by the former. Nothing can be superior to a well-made, fine, white bristle tool, in larger work; or to a good red sable for details.

Hog-hair Tools.—These brushes are made both round and flat. Flat hog-hair are generally more useful than round ones; they are preferred, as assisting in giving a squareness and crispness of touch. They should be strongly and neatly made; and in selecting them be sure that the hair has not been cut at the points, for this is sometimes done with inferior brushes; but such brushes have an unpleasant and coarse touch, laying on the colour in a scratchy manner. It will be found to be a good test, if they be made of a very fine silky-looking hair, and be very soft to the touch. They should however be firm, yet elastic; springing back to their form after being pressed laterally upon the hand. Lastly, the shape should be flat and wedgelike, without straggling or diverging hairs. Let the handle be of cedar, and polished; the cedar is pleasant and light to hold, and being polished is easily cleaned. The old white pine handles, sooner becoming ingrained with colour, are both dirty and disagreeable to work with.

Sable Brushes.—The observations regarding hog-hair tools will apply to the sable tools; but these latter should have the additional property of coming to a fine, yet firm point. Be careful in choosing sable brushes, the hair of which is of a pale yellowish cast; and see that the brush is firm, and that it springs well to its point. The round sable tool is as serviceable as the flat one, and is used in working the finishing parts of a painting. Round brushes in quills, known by the name of sable pencils, are also applicable to the same purpose. Pencils that bag or swell where the hair is inserted in the quill, or the hairs of which diverge and form several points, are worthless.

Badger Tools are of various sizes; and the hair, instead of coming to a close end or point, as in other brushes, diverges or spreads out, after the manner of a dusting brush. When good, the hair is long, light, and pliant, of a reddish brown or black, with clean white ends. The chief use of the badger tool is to soften or sweeten broad tints, such as skies, water, distances, and the like; it is a very valuable assistant to the young painter; but must be used with caution, because its injudicious use frequently destroys forms, and produces woolliness. If the badger tools be much employed on a large surface of colour, the points of the hair frequently become so loaded with colour, that it is necessary to clean often. This is best done by pinching up the brush rather tightly at the ends, and wiping it on a clean rag. The brush is thus kept free from colour during the progress of the work, which might otherwise be sullied and deteriorated in the purity of its tones. The badger brush is also useful to the landscape painter, for carrying minute points of colour into those wet parts of the work which require to be lightened, enriched, or varied.

Cleaning Brushes.—All brushes, after being used, should be carefully cleaned. This is best effected by immersing the hair of the brushes in a little raw linseed oil; the oil should afterwards be washed out with soap and warm water, till the froth which is made by rubbing the brushes on the palm of the hand is perfectly colourless. The brushes should next be rinsed in clean water, and the water pressed out by a clean towel. The hair should then be laid straight and smooth, and each brush restored to its proper shape, by passing it between the finger and thumb, before it is left to dry. Care should be taken not to break the hair by too violent rubbing, as that would render the brushes useless. Many painters use turpentine instead of linseed oil in the cleaning of brushes; it effects the object more quickly, but the only use of turpentine that should be permitted, is to rinse the brushes in it slightly, when it is required to clean them quickly; on no account should they be permitted to remain soaking in the turpentine, as this practice is certain to injure the brushes, rendering the hair harsh and intractable, and frequently dissolving the cement by which the hair is held in the socket of the handle.

Canvas.—This is the general material used for painting. It is kept prepared in rolls of various widths, and is sold also strained on frames of any required size. The ground or preparation of the canvas should be thin, yet completely covering the threads of the fabric; and it should be free from projecting lines and knots.

Take suitable new canvas, stretch it well upon a stretching frame, wet it well with clean water, and afterwards dry it thoroughly; then stretch it a second time. Grind equal quantities of white-lead and whiting, well dried, with five parts of raw oil, and add one part boiled oil; prime the cloth over on the face with a brush, palette knife, or trowel; the last is preferable to those who can use it. After the canvas has had sufficient time to dry, scrape off from the back any superabundant colour which may have passed through it; then repeat a second coat on the face, leaving it as smooth as possible. When hard and dry, rub it smooth with a piece of light pumice and water, so as to cut off or lay all the knots in the canvas; then grind two parts white-lead, two parts whiting, and one part burnt ochre, with a small quantity of pumice, all well ground separately rather stiff in raw oil; afterwards mix the whole, adding a little gold size, dilute with half raw oil and half turpentine, and apply a third, fourth, or fifth coat; repeat rubbing down with pumice and water until smooth enough for painting upon.

Oil Sketching Paper is an extremely serviceable material for the young artist. It is made of drawing paper, covered with two or three thin coats of oil colour, so as to furnish a ground similar to that of prepared canvas. It is cheap and portable, and serves very well for early attempts and for preparatory sketches; for trying the effects of any work previous to its commencement, as well as during its progress. The paper has this advantage, that, if the sketch is required to be preserved, it can readily be pasted or glued upon the canvas, and then mounted on a deal frame, when it will present the appearance of strained canvas.

Grounds.—Much diversity of opinion has existed respecting the colour of the surface of the prepared canvas. It is a subject of considerable importance, for it is impossible to paint a richly-coloured picture, with life and warmth, upon a dull unsuitable ground. A landscape, if carefully handled, can be brought on and finished in a more brilliant manner on a white ground than on any other. It has however been objected to a purely white ground, that it is liable to impart a cold chalky effect; but it must be remembered that what is at first white in oil, becomes in a short time of a yellowish hue, and its coldness of tone is thereby lowered. The white, or pale cream-coloured, and pale warm drab-coloured grounds, seem to surpass all others. The reason is that they throw a light, and consequently a transparency, through the work; and, as all colours in oil painting have a tendency to sink into the ground on which they are laid, and to become darker, this tendency can be counteracted only by having grounds of considerable lightness and brilliancy.

Cold grey grounds have been used in landscape painting; but they impart a heaviness of colouring much to be avoided. Some artists have painted on grounds of a dull red or leather-coloured tint, and much richness may be gained by such; but after a time the colours of any portion that may have been thinly painted sink into this strong ground, and the effect produced is heavy and disagreeable. Upon the whole, a white ground is to be preferred, as soon as the learner has acquired some experience of the subsequent effect of his colours; but as the inexperienced find much difficulty in preventing the coldness and poverty of expression which it is likely to cause under their hands, it will be advisable for the beginner to take the usual light stone drab that is generally given to canvas; for it furnishes him with a middle tint or tone to start from, which, when visible in shadows and middle tints, has not the raw chalkiness shown under similar circumstances on an unskilfully or imperfectly covered white ground.

Vehicles are used to temper and thin the colours, for the purpose of bringing them to a proper working state. All oils or varnishes act more or less to the eventual prejudice of the colour with which they are combined for application. What is desired in oil painting is a vehicle which, while it has an agreeable working quality, shall neither change nor be degraded by time, nor interfere with the purity of the tints as they appear at the moment they are first laid on—a vehicle, that shall neither perish nor crack as it becomes old.

Oils.—Linseed, poppy, and nut oils are the fixed oils used as vehicles; turpentine and occasionally spike-lavender are the essential oils so used. Of the fixed oils, linseed is in most common use. It should be of a pale amber colour, transparent, and limpid; and, when used in moderately warm weather, it should dry in a day. The most valuable qualities of linseed oil, as a vehicle, consist in its great strength and flexibility. It is by far the strongest oil, and the one which dries best and firmest under proper management. The next in importance is poppy oil. It is inferior in strength, tenacity, and drying, to linseed oil; but it has the reputation of keeping its colour better than linseed oil; and it is on this account generally employed in grinding white, and most of the light pigments. Nut oil is more uncertain in its qualities than either linseed or poppy oil; and is frequently extremely long in drying. Poppy oil, however, supplies its place so well, that it is not commonly required. Oils are all more or less influenced in their drying by the colours with which they are combined; some of which greatly accelerate, while others retard it. With certain colours some oils will scarcely dry at all, unless means are employed to cause them to do so.

Japanners' Gold Size is sometimes employed as a powerful means of drying dark and transparent colours, which are in general comparatively bad dryers.

Megilps.—The vehicles known by this name are in great favour with artists. They possess a gelatinous texture, which enables them, while flowing freely from the pencil, yet to keep their place in painting and glazing. The megilp generally in use is formed by mixing together equal parts of strong mastic varnish and drying oil. After remaining undisturbed for a few minutes, it assumes a gelatinous texture, resembling a thin, transparent, amber-coloured jelly. Megilp varies in colour, as it is made with either a pale or deep-coloured drying oil. The palest is made by using instead linseed oil, in which a small quantity of finely-ground sugar of lead has been diffused. With equal parts of this compound and of mastic varnish, a very light megilp is obtained. Another megilp is made by mixing 1 part of a saturated solution of sugar of lead in water, with two parts of linseed or poppy oil. These are well stirred or shaken together till they are combined; and then 2 parts of mastic varnish are added, and well mixed with the preceding. By this means a white creamy emulsion is obtained, which, though opaque in use, becomes quite transparent as it dries. A compound used occasionally in combination with megilp, and consisting of 1 part of copal varnish, 1 part of linseed or poppy oil, and 1 part of turpentine, will furnish a pleasant and serviceable vehicle for general use. Care must be taken, however, to force its drying by the addition of ground sugar of lead, when employed with slowly-drying pigments.

Glazing.—A glaze is a thin transparent film of colour, laid upon another colour to modify the tone, or to aid the effect of the latter; the work thereby appearing distinctly through the superimposed layer of glaze, from which it receives a characteristic hue. Glazing is effected by diluting proper transparent colours with megilp or other suitable vehicle. Thus diluted, these colours are laid upon portions of the work, either in broad flat tints, or in touches partially and judiciously distributed. The object of this process is to strengthen shadows, and to give warmth or coldness to their hue: to subdue lights that are unduly obtrusive, or to give additional colour and tone to those that are deficient in force and richness. Should it be necessary to lighten the tone of any part of the picture, this cannot be done by merely glazing; the first tints must first be concealed with brighter colours, of sufficient body for that purpose, and the glaze may then be applied. The glaze should usually be darker than the ground colour upon which it is to be laid; and as a rule, it may be observed that the first painting of the picture should be brighter than the subject may require, in order that the subsequent glazings may lower and obscure it to a proper and effective degree of tone. Glazing is generally effected by the application of diluted transparent colours; but occasionally semi-transparent colours are used for this purpose, provided they are rendered sufficiently transparent by the admixture of a large proportion of vehicle. These latter glazings are capable of being applied with excellent effect, where it may be necessary to modify the tones of those parts of the picture which do not appear satisfactory, or to produce particular effects, such as representations of smoke, dust, mists, and the like. Caution is however, necessary in glazing with opaque colours; because, if used in excess, they will deteriorate the picture, by destroying its transparency. Should a glazing produce a result different from what was intended, the glaze may easily be removed by a rag, or, if the spot be small, by the finger, provided the removal be effected *immediately*, that is, before the glaze has had time to fasten itself upon, or to soften, the colour on which it is laid, and in no case must glazing be attempted before the colours over which it is laid have become perfectly dry and firm.

Impasting. — In oil painting, the shadows or dark portions of the picture are painted thinly, while the lights are laid on or impasted with a full pencil and a stiff colour. In the lights of the foreground, and of parts not intended to be remote, or to retire, the impasting should be bold and free; while, in the more brilliant lights, it cannot well be too solid. There is, however, a reasonable limit to the practice; since actual protuberance or prominence of the paint itself will, in certain lights, produce a false shadow, and therefore a bad and false effect. This will be understood, from observing that the loading of thick masses of colour upon the picture, so as to make them project considerably from the surface, is done with the view of their being strongly illuminated by light actually incident upon the picture, and of thus mechanically aiding in the production of roundness and relief, or in giving a sparkling effect to polished objects or glittering points. But this artifice must be had recourse to sparingly and cautiously, else it defeats its own object, and produces a coarse and vulgar air and effect. The palette knife has always been a favourite instrument of this impasting, or laying on of colour, capable as it is of producing an agreeable brightness on, and of giving an appropriate flatness to, the pigment. A clear and appropriate tint, for instance, skilfully swept across a sky by these means, often produces a surprisingly brilliant and charming effect.

Scumbling.—Scumbling, the opposite process to that of glazing, is done by going lightly over the work with an opaque tint, generally produced by an admixture of white. For this purpose a hog-hair brush is employed, charged with colour but sparingly; and with it the tints are drawn very thinly, and somewhat loosely, over the previous painting, which should, as in the case of glazing, be dry and firm. Scumbling is used to modify certain effects, by rendering the portion to which it is applied cooler, greyer, and in fact less defined than it was before, and to give air and distance to objects that seemed too near. It is thus of service both in correcting a tendency to muddiness or dirtiness of colour, and to what may be called hardness or over-distinctness of detail, and in weakening the force of colours that are too powerful by softening and uniting such tints as may be too violently contrasted. It is desirable to avoid, as far as possible, scumbling over shadows, as an inexperienced hand might thus destroy their transparency.

Lining Old Paintings.—(*a*) Take a piece of unbleached calico, strain upon a frame, and size it with weak size. When dry, take ¼ oz. spirits of turpentine, 1 dr. camphor, dissolve in it 4 oz. cold-drawn linseed oil, 2 oz. white-lead, 2 oz. stiff ground umber, 4 oz. finely-washed and dried whiting. Mix all together; apply it to the calico, well rubbing it in; after the second coat, pumice to erase the lumps. Give the picture a coat, and pumice that; then coat both, and put them together upon a level board face down upon a piece of brown paper well sized. Well press, and rub the air out, so as to bring them in perfect contact, and in a few days it may be tacked upon a frame.

(*b*) Make a temporary stretcher, and let it measure inside a little larger than the outside of the picture about to be lined, and on it stretch some unbleached calico; trim the picture square, cutting off all the old and ragged edges. Oil a piece of paper the size of picture with linseed oil, and lay it on a flat surface; now lay the picture face downwards on the oiled paper, and coat it with glue or paste until there is sufficient to make it stick well; then lay the unbleached calico on, rub well with the flat of the hand, iron it with flat iron till quite dry, taking care to put a piece of paper between the calico and the iron, or it may stick. Be sure the iron is not too hot; and if it is a large picture, it will be as well to have two irons, one getting hot while the other is in use. When the picture is quite dry it is ready for putting on the new stretcher, which should be one with two cross-bars, and can be obtained at any artists' colourman's. If you cannot make some good stout paste yourself, you had better buy it at the leather seller's, add glue enough to make it a good strength, and let the two be well mixed together.

Preserving a Scaling or Cracked Painting.—The preparation is a mixture of equal parts of linseed oil and methylated chloroform, which is poured over the painting if the colours are too brittle to bear the friction of a soft brush. After remaining on the surface of the painting for a day or two, the excess of oil may be removed by means of a piece of cotton-wool, or a soft brush, a fresh portion of the preservative applied, and the excess removed as before. The process must be repeated from time to time until the colours are firmly fixed, when the painting will bear friction, and may be submitted to the cleaning process, or varnished. It is advisable, however, to remove as much of the dirt as possible from the picture, by careful washing with soft water, previously to the application of the fixing agent. The mixture will not restore the cracks in a painting, but simply fixes the colours, and renders the painting very elastic. A mixture of one part of methylated chloroform and two of linseed oil is used for reviving the colours of paintings. A small portion is rubbed over the pictures, after washing, with cotton-wool, and on the following day the painting is wiped over with a soft silk handkerchief. Oil and chloroform, when used in the proportion given, possess the property of restoring the faded colours of paintings, and develop colours which have perished, to the eye, by age.

Varnishing valuable Paintings.—Some artists employ for new paintings white of egg as a varnish, others do not varnish their paintings for one or two years after being finished, when the colours are completely hardened and mellow. Mastic varnish is the only one which can be removed at pleasure, and for that reason is generally preferred to all others, although it is very liable to chill; that is, it becomes all over of a bluish steamy hue, which obscures the beauty of the painting, and appears disagreeable to the eye. Many circumstances contribute towards causing it to chill; for instance, varnish made from weak, unripe gum mastic and common spirits of turpentine will chill, particularly if applied on new paintings, where the grounds, oils, and colours are fresh, soft, and absorbent. In order to prevent this, if possible, employ no varnish but that made from fine, ripe gum mastic and rectified turpentine. Varnish for oil paintings, after being properly made, ought to stand for at least twelve months in large wide-mouthed glass bottles, without a cork, covering the mouth with a piece of glass, so as to admit the air, but prevent dust falling in; place the bottle so as to receive a full light, but no sun. The light and air so change and modify the essential quality of the turpentine, that the varnish becomes elastic, clear, and brilliant, having so much improved during that time as seldom or never to chill or become steamy, and by age it loses that attraction which all new-made varnishes possess for moisture and impure exhalations. Therefore, as a preventive against varnish chilling, employ none but good old varnish; never apply it on new or old paintings until properly cleaned, and well dried from moisture; apply the varnish in a warm room, where the painting and varnish also receive a proper warmth; after the varnish is applied, let it remain until properly dry; recollecting that with all newly-painted pictures, where the grounds and colours are soft and absorbent, and where the pictures are afterwards exposed to strong, moist exhalations, the varnishing in time will chill; but when paintings are properly cleaned and varnished, and afterwards hung up in dry rooms or galleries, there is no reason to fear their chilling.

Harmony of Colours.—Harmony of colour is produced by an equable use and distribution of the primary colours, whether used simply as such, or united in various proportions in their compounds. Harmony is recognised in a picture when nothing exists in it that disturbs the eye by violent opposition or contrast of colours; judicious contrast, however, tends much to produce harmony, when the force of the contrast is diminished by the juxtaposition of tones partaking more or less of the colours employed in producing the contrast. This we shall find is the process employed by nature, the reds in which are harmonised with the contrasting green by hues of orange, or yellow green; and so with other colours. Harmony of colour in painting is best obtained by setting the palette with those pigments which, through the prevalence of any of the primaries, blend with, or, as it were, run into each other. Thus, commencing with white, we proceed to yellow, orange or yellow-reds, red, blue-reds, blues, green-blues, greens, browns, grey, and black. A palette can be set warm or cold, as the subject may require, by selecting pigments in which blue predominates or is deficient.

Primaries.	BLUE is contrasted by ..	Red and Yellow,	or Orange.	Secondaries.
	RED is contrasted by ..	Blue and Yellow,	or Green.	
	YELLOW is contrasted by ..	Blue and Red,	or Purple.	
Secondaries.	Orange, or	Red and Yellow,	is contrasted by BLUE.	Primaries.
	Green, or	Blue and Yellow,	is contrasted by RED.	
	Purple, or	Blue and Red,	is contrasted by YELLOW.	

Plaster.—Five coats are generally requisite to paint plaster well; but where it is not of a very absorbent nature, four are found to answer. The first is composed of white-lead, diluted with linseed oil, to rather a thin consistency, in order that the plaster may be well saturated; and into this is put a small quantity of litharge to ensure its drying. In painting quick plaster, the oil in this coat is entirely absorbed, thus hardening it to the extent of about $\frac{1}{8}$ inch inwards from the surface. When this is found to be the case, the second coat should also be thin, that the plaster may be thoroughly saturated; and it will be found necessary after this to give other three coats, making in all five. The second coat will be found to be but partially absorbed, and it is therefore requisite to make the third coat a good deal thicker, and to introduce into it a little spirits of turpentine, and such of the colouring pigments already enumerated, as may bring it somewhat near to the tint in which the apartment is to be finished. The fourth coat should be as thick as it can be well used, and should be diluted with equal parts of oil and spirits of turpentine. The colour of it ought to be several shades darker than that which is intended for the finishing coat, and the drying ingredient sugar of lead instead of litharge. These coats ought all to be laid on with much care, both as to smoothness and equality, and each lightly rubbed with sand-paper before the application of the next. The finishing or flatting coat, as it is termed, from its drying without any gloss, is next applied. It ought, like others, to be composed of pure white-lead, ground as already described, and diluted entirely with spirits of turpentine; and it should appear, when mixed, a few shades lighter than the pattern chosen for the wall, as it darkens in the drying. The drying ingredient should be a small portion of japanners' gold size. This coat must be applied with great care and despatch, as the spirits of turpentine evaporate very rapidly, and if touched with the brush after that takes place, which is in little more than a minute after its application, an indelible glossy mark will be left on the surface. Nothing has been said of the time that each of the coats will take to dry sufficiently to receive the next, as that depends much upon the state of the weather, the quantity of dryers employed, and the atmosphere kept up in the apartment. It may be observed, however, that under any circumstances the first coat ought to stand a few days before the application of the second; the second a little longer before the application of the third; and the third, unless in four-coat work, should have still longer time to harden. But the coat immediately before the flatting or finishing coat ought not to stand above two days, as much of the beauty and solidity of the work will depend on the latter dying into and uniting with the former.

Sign Boards.—Sign or pattern boards ought to be chosen of old well-seasoned wood; oak or mahogany is much the best, but many are made of pine, which ought to be sound, straight, close-grained, well dried, and made with pieces let in across the back, to prevent warping. Thus prepared, brush the board over back and front with equal quantities of raw linseed oil, japanners' gold size, and turpentine, to which add a little ground white-lead, driving or rubbing out the colour well. For the second coat, take equal quantities of white-lead, common spruce ochre, and whiting, all well dried, and ground fine and stiff, separately with raw oil; mix the whole together; add sufficient of gold size to cause it to dry quickly, firm, and hard; dilute with turpentine to a proper consistence, and apply two or three coats of the above colour. When dry and hard, rub it smooth with either sand-paper or pumice and water; then grind equal portions of spruce ochre, whiting, bath-brick, and white-lead, with two parts oil and one part turpentine, adding a little gold size, diluted with turpentine, and apply one, two, or three coats, if necessary, taking care to rub down and wash off the panel after each coat, repeating rubbing and colouring until the panel is as smooth and level as plate glass; it is then fit to receive the required last coat, to write, marble, paint, or grain upon. The finishing application, whether it be a plain ground, landscape, figure, or letters, ought to stand until thoroughly dry and hard; it should finally be varnished twice over with best body copal or amber varnish, as the delicacy of the painting will admit.

Transparent Painting on Linen. — The colours used in transparent painting are mixed with megilp as a vehicle, except in the case of very light colours, when turpentine and copal varnish must be used. The material upon which transparencies are executed is fine muslin; and this, before being worked upon, should be strained in a straining frame, and sized with either gilders' size, isinglass size, or fine colourless gelatine dissolved and properly diluted. After the first coat of size is dry, the muslin will slacken and hang loosely on the frame. It should be stretched; another coat of size applied; and, when dry, the muslin again extended. A small piece of muslin should at the same time be prepared as a trial-piece, strained in the same way as the larger piece, and when dry it can be used to determine whether the muslin is sufficiently sized, or whether the colours are in working condition. The design having been prepared, it may be traced, copied, pounced or stencilled upon the prepared muslin, care being taken that the outline from which the tracing is made consists of strong and decided lines, that stencil plates are made of oiled paper, and that powdered charcoal is used in preference to any other powder for pouncing. The instructions for oil painting will apply equally to painting transparencies, except that for very fine tints sponge can be used with great advantage to rub in broad flat tints, however delicate. Fine effects may be produced by the use of two transparencies, arranged one behind the other. On the front surface is painted all that is required to be seen in the clearest relief, the painting on the surface behind being modified in its effect by being seen through the front surface.

Transparent Painting on Paper.—The same colours as those of landscape painting are used for transparencies, and the processes are also the same; only it is requisite to be very attentive in washing in the tints with the utmost possible correctness, both with respect to form and to the power of colour, as the surface of the paper must be preserved clear in every part, and this clearness is always more or less injured by washing out or sponging. The paper should be the thinnest hand-wove drawing paper that can be procured, carefully selected, and free from unevenness or inequality of texture. When the paper has been selected according to the size of the proposed subject, it should be laid on a drawing board and fastened there, with a piece of thick paper beneath, in order that the tints may be distinctly seen during the painting. After having completed the subject so far as relates to the front, it may be cut off, leaving a margin $\frac{1}{4}$ inch in breadth, for the purpose of gluing it down in the following manner. Take a sheet of Bristol-board, or if the subject is larger, a thicker material, for the purpose of preserving the surface of the whole even and flat. From the centre of this board let a piece be cut out corresponding with the size of the painting, which must be placed on a drawing board, with its face downwards. Let it then be covered for a few minutes with a damp cloth, to cause it to expand a little; and in the meanwhile cover, with thick gum or glue, the edges of the aperture in the board, to correspond with the width of the margin cut off with the painting. The damp cloth may now be removed, and the painting turned with its face upwards, placing the board upon it accurately, in such a manner that the margin may adhere securely to the gum or glue in every part. The whole may then be laid on a flat surface to dry. In this way the Bristol-board will form a frame of such width as may be adapted to the painting, and this frame may be afterwards ornamented according to the taste or fancy of the student. It may be observed that the brilliancy of a transparent painting will be increased by the opacity of the border by which it is surrounded, and its width should be regulated by the size of the painting. As soon as the whole is thoroughly dry, the painting must receive such additions at the back as may be requisite to bring it up to the full luminous effect intended. For this purpose, the most convenient position will be one inclined similar to an artists' easel, and immediately in front of a steady light. When the painting has been placed in this position, it will immediately be perceived, that however strongly it may have been previously tinted or touched in the front, a strong light will cause it to appear comparatively feeble. But as the original intention of the workman will still be impressed on his mind, this weakness in the effect, which only becomes apparent by transmitted light, will suggest the addition of tints to produce the intended power. Where more is required, it must be cautiously applied at the back of the painting, taking all possible care to preserve the colours clear, and not to injure or ruffle the texture of the paper, repeating the tints till the due power is obtained. When considerable power is required, such colours of Indian red, Cologne earth, or vermilion, must be selected as have a semi-opaque body; but care must be taken not to lay them on so thickly as to produce blackness. When richness is required, lake, Prussian blue, and gamboge, which are perfectly transparent, are well adapted to communicate not only richness but delicacy and power to finish. When, by carefully employing the means just pointed out, all possible harmony and effect have been imparted to the painting, it may be rendered partially or wholly luminous, by judiciously applying mastic spirit varnish. With a camel-hair pencil moderately charged with this varnish, let such parts as are in the highest lights be carefully touched, as well as the major part of the sky, and the principal objects of the piece, together with whatever part may require it, in accordance with the character of the scene. If the whole of the subject is covered, it will be requisite to spread the varnish with a flat camel-hair brush, passing it quickly from side to side, and from top to bottom, so that the varnish may be equally spread with all possible expedition. The picture must then be left to dry. After the varnish has become dry, by mixing a little ox-gall in the water used for the colours, additional beauty of tint, as well as harmony, may be imparted to such parts as appear crude or harsh.

Water Colour.—The practice of the art consists of sketching the outline, of tinting or shading with sepia, bistre, or india-ink; and of the application of the pigments, in three or more successive stages, to the attainment of a finished drawing. Instructions must, of necessity, be of a general character, because almost every artist of genius finds out for himself and practises some peculiar methods of applying the pigments, which can only be learned by those who become his pupils. These peculiar methods constitute the various styles of the masters of the art, by which their works are so readily recognised and distinguished.

Materials.—The principal materials required by the painter in water colours are drawing paper, ivory for miniatures, drawing board, pigments or colours, lead pencils, hair pencils or brushes, palettes, slabs, saucers, cups or glasses for holding water, sponge, gum water, ox-gall, rubber, drawing pins, sharp convex-pointed knife, and flat ruler.

Room.—The choice of a situation for the practice of painting is not a matter of indifference. The room should be well lighted, of a northern aspect, if possible, and free from reflected colours from opposite objects. As dust and grease are inimical to the delicacy and integrity of water-colour painting, it will be the first care of the student to guard against them. The light should fall on the left hand of the painter, and not be admitted below the head. A room lighted from above, or by a skylight, is much to be preferred.

Pencils or Brushes.—The hair pencils or brushes used in water-colour painting are made of camel-hair and of fitch or sable. The best are those known as soft brown or black sables; those made of red sable are not so useful, as they possess the bad quality of stiffness, and disturb the colours by their harshness. These brushes will hold a considerable quantity of fluid, and should be used full, but not overflowing so as to become unmanageable. After using, they should be carefully washed in clean water, and then slightly pressed in a piece of clean linen rag. A brush put away unwashed, especially if it has been used for india-ink, or any dark pigment, can scarcely ever be cleaned again so as to be fit to use with light or delicate pigments. For large drawings, brushes are prepared, both round and flat, mounted in tin; these are also useful in washing. The most essential quality of a good pencil is that it should yield a good point, for it is that part only which is used; the hairs when moistened should form a cone terminating in a fine and delicate point. It should also be firm yet elastic, returning to a straight direction immediately upon being lifted from the paper.

Management of Drawing.—The manipulation in water-colour painting is of the greatest simplicity, consisting merely in selecting the pigments required, mixing from them the various tints the subject demands, and leaving them in their proper places upon the paper. These pigments are rubbed with boiled or distilled water, on earthenware slabs, with the addition of a small quantity of gum water, for the strong marking of the shadows, and so on. It is the usual practice to lay on the first tints or washes with the hard-cake pigments ground on the slabs, while the middle or foreground is painted with the soft or body-colours, which, by remaining constantly moist, are always ready for use. The pigments should be ground in sufficient quantity, and with so much water as to be quite fluid, and capable of entirely filling the brush; the superfluous quantity can be easily removed by slightly pressing the brush on the edge of the palette; for unless the pigments are reduced to this state of fluidity, the drawing acquires a dry and harsh appearance; while, at the same time, an excess of fluidity produces a thinness and meagreness, leaving a dark edge surrounding the coloured surface, which inevitably betrays the inexperienced hand. The progress of a water-colour drawing is from simply washing with the requisite colours, as a preparatory stage, and proceeding by gradual and delicate additions where they are required, and so on to the finishing, which consists in applying the colours in their full body and strength, giving solidity to the forms, and a definiteness to the outlines that constitutes a finished picture, equal in vigour, freshness, and richness of tone to oil painting. Many parts of the drawing must unavoidably be gone over with colour that should be left white for the high or brilliant lights: the colour must be removed from these places by rubbing with a sharp scraper or by moistening the spot to be reclaimed with a pencil dipped in clean water; after it has remained a few moments, the moisture is removed with a piece of clean blotting paper, and then rubbing the surface of the paper by means of a white handkerchief, rubber, or bread-crumbs.

Wirework.—Boil good linseed oil with as much litharge as will make it of the consistency to be laid on with the brush; add lampblack at the rate of 1 part to every 10 by weight of the litharge; boil three hours over a gentle fire. The first coat should be thinner than the following coats.

Zinc.—Dissolve 1 part of chloride of copper, 1 of nitrate of copper, and 1 of sal ammoniac, in 64 parts of water, and add 1 part of commercial hydrochloric acid. Brush the zinc over with this, which gives it a deep black; leave to dry 24 hours, when any oil colour will firmly adhere to it, aud withstand both heat and damp.

PAPER.

(ii. 387.)

Enamelled.—1 lb. of parchment cuttings, $\frac{1}{4}$ lb. of isinglass, and $\frac{1}{4}$ lb. of gum arabic, in 4 gal. of water, are boiled in an iron kettle until the solution is reduced to 12 quarts; it is then removed from the fire and strained. The solution is divided into three parts of 4 quarts each; to the first portion is added 6 lb. of white-lead, ground fine in water; to the second portion is added 8 lb. of white-lead, and to the third is added 6 lb. of white-lead. The sheets of paper are stretched out upon flat boards and brushed over with a thin coat of the first mixture with an ordinary painters' brush; the paper is then hung up to dry for 24 hours. After this, the paper is ready to receive a coat of the second mixture, and again hung up to dry for 24 hours; the paper is then treated in the same way with the third mixture, and dried for 24 hours. After this it receives a high gloss, which is obtained by laying the work with its face downwards on a highly-polished steel plate, and then passing both with great pressure between a pair of powerful rollers. It is to be regretted that this enamelled surface is not very durable, as it comes off after wetting. To prevent this, a solution of some resinous substance may be added in the last operation.

Incombustible paper may be made by mixing with the pulp a fluid obtained by addiug to an aqueous solution containing $1\frac{3}{4}$ oz. of pure tallow soap, just enough alum to completely decompose the soap. The paper made with this requires no size. (See also ii. 299.)

Ivory Paper.—The properties which render ivory so desirable for artists are, the evenness and fineness of its grain, its allowing all water colours laid on its surface to be washed out with a soft wet brush, and the facility with which the artist may scrape off the colour from any particular part, by means of the point of a knife, or other convenient instrument, and thus heighten the lights in his painting more expeditiously and efficaciously than can be done in any other way. These advantages are obtained in the paper made according to the following receipt, without any of the disadvantages of ivory, such as its limited size and changeable colour. Traces made on the surface of ivory paper by a hard black-lead pencil are much more easily effaced by rubber than from common drawing paper, which, together with the extremely fine lines which its hard and even surface is capable of receiving, peculiarly adapts it for the reception of the most delicate kind of pencil-drawing and outlines. The colours laid upon it have a greater brilliancy than upon ivory, owing to the superior whiteness of the ground.

Take 1 lb. of clean parchment cuttings and put them into a 2-quart pan, with nearly as much water as it will hold; boil the mixture gently for 4 or 5 hours, adding water from time to time to supply the place of that driven off by evaporation; then carefully strain the liquor from the dregs through a cloth, and when cold it will form a strong jelly, which may be called size No. 1. Return the dregs of the preceding process into the pan, fill it with water, and again boil it as before for 4 or 5 hours; then strain off the liquor, and call it size No. 2. Take three sheets of drawing paper—outsides will answer the purpose perfectly well—wet them on both sides with a soft sponge dipped in water, and paste them together with the size No. 2. While they are still wet, lay them on a table, and place them upon a smooth slab of writing slate somewhat smaller than the paper, turn up the edges of the paper, and paste them on the back of the slate, and then allow the paper to dry gradually. Wet as before three more sheets of the same kind of paper, and paste them on the others, one at a time; cut off with a knife what projects beyond the edges of the slate, and when the whole is perfectly dry, wrap a small piece of slate in coarse sand-paper, and with this rubber make the surface of the paper quite even and smooth. Then paste on an inside sheet, which must be quite free from spots or dirt of any kind; cut off the projecting edges as before, and when dry rub it with fine glass-paper, which will produce a perfectly smooth surface. Now take ½ pint of the size No. 1, melt it with a gentle heat, and then stir into it 3 table-spoonfuls of fine plaster of Paris; when the mixture is complete, pour it out on the paper, and with a soft wet sponge distribute it as evenly as possible over the surface. Then allow the surface to dry slowly, and rub it again with fine glass-paper. Lastly, take a few spoonfuls of the size No. 1, and mix it with three-fourths its quantity of water; unite the two by a gentle heat, and when the mass has cooled so as to be in a semi-gelatinous state, pour one-third of it on the surface of the paper, and spread it evenly with the sponge; when this has dried, pour on another portion, and afterwards the remainder; when the whole has again become dry, rub it over lightly with fine glass-paper, and the process is completed; it may accordingly be cut away from the slab of slate, and is ready for use. The quantity of ingredients above mentioned is sufficient for a piece of paper 17½ by 15½ in. Plaster of Paris gives a perfectly white surface; oxide of zinc mixed with plaster of Paris, in the proportion of 4 parts of the former to 3 of the latter, gives a tint very nearly resembling ivory; precipitated carbonate of baryta gives a tint intermediate between the two.

Lithographic Transfer.—Make strong separate solutions in hot water of gum arabic 2 parts by weight, starch 6, alum 1. Mix, and whilst moderately hot, give the paper two or three coats with a brush, allowing each coat to dry before the next is applied; finish by pressing. Another plan is to smear the paper with several cold coats of thin size, and then use solutions of white starch and gamboge water, allowing each coat to dry as before. Paper thus prepared is written on with litho. transfer ink, the back wetted, placed on a clean stone, and run through the press, when a reverse copy is obtained, which can be printed from in the usual way. (See also ii. 393.)

Manifold Writing.—The white paper is only very fine thin writing paper. The black is soft paper, prepared by being smeared with a composition of grease and plumbago or lampblack; this mixture is allowed to remain on for 12 hours, and the paper is then wiped smooth with a piece of wool or cotton-waste. Place white paper over black, and write with a blunt point.

Powder.—Boil white paper, or paper

cuttings, in water for 5 hours. Pour off the water, pound the pulp in a Wedgwood mortar, and pass through a fine sieve. This powder is employed by the bird stuffers to dust over the legs of some birds, and the bills of others, to give them a powdery appearance; also to communicate the downy bloom to rough-coated artificial fruit, and other purposes of a similar nature; it makes excellent pounce.

Staining.—Crimson.—A very fine crimson stain may be given to paper by a tincture of Indian lake, which may be made by infusing the lake some days in spirits of wine, and then pouring off the tincture from the dregs. It may be stained red by red ink. It may also be stained of a scarlet hue by the tincture of dragon's-blood in spirits of wine, but this will not be bright.

Green.—Paper or parchment may be stained green, by the solution of verdigris in vinegar, or by the crystals of verdigris dissolved in water.

Orange.—Stain the paper first of a full yellow by means of tincture of turmeric; then brush it over with a solution of fixed alkaline salt, made by dissolving ½ oz. of pearlash, or salts of tartar, in a quart of water, and filtering the solution.

Purple.—Paper may be stained purple by archil or by tincture of logwood. Brush the work several times with the following logwood decoction:—1 lb. of logwood chips, ¼ lb. of Brazil wood, boiled for 1½ hour in a gallon of water. When dry, give a coat of pearlash solution, 1 dram to a quart, taking care to lay it on evenly. The juice of ripe privet berries expressed will also give a purple dye.

Yellow.—Paper may be stained a beautiful yellow by tincture of turmeric formed by infusing an ounce or more of the root, powdered, in a pint of spirits of wine. This may be made to give any tint of yellow, from the lightest straw to the full colour, called French yellow, and will be equal in brightness to the best dyed silks. If yellow be wanted of a warmer or redder cast, annatto or dragon's blood must be added. The best manner of using these is to spread them evenly on the paper by means of a broad brush, in the manner of varnishing.

PAPER-HANGING.

If the walls are quite new and smoothly finished, the only preparation usually necessary is to lay on a thin coat of weak size, the use of the size being to make a surface to which the paper will stick better than to the bare wall. In preparing an old whitewashed or coloured wall for paper, the wash or colour is wetted with water and scraped off with an old plane-iron, or any piece of steel which has a smooth edge, after which the wall should be swept down with a stiff broom, to remove all that the scraper may have left, and make an even surface. If there is any loose plaster, those parts should be well sized and have a piece of thin strong paper pasted over them; but the best way is to get the place replastered. Cracks or holes may easily be filled with a little putty; in no case should they be left. If not stopped in any other way, slips of paper should be pasted over them, or else the cracks will soon show through the outer paper. After all this is done, the room may be sized, and the size will be dry enough in an hour for the papering to be commenced. If the room has been already papered, it will be necessary to go over the walls and tear off all the loose pieces, especially at the top and bottom, corners, and edges. If the bare wall is exposed by the tearing off, these spots should be sized. The walls of rooms finished in a superior manner are generally plastered three coats, and upon the plaster, when quite dry, a coating of lining-paper is laid, to obtain a smooth surface. Sometimes common thin canvas is used instead of lining-paper, and occasionally instead of plaster. In the latter case, battens should be fixed against the walls, to fasten the canvas to, and prevent it touching the walls. The preparations having been made, the hanging of the paper may be proceeded with: the rule is, that the edges of the paper, when hung, shall be towards the window. The appearance of many a handsome paper has been spoiled from carelessness or ignorance in this particular; but when this precaution is observed, the lapped joints scarcely show. First of all, the edges of the paper are to be cut, and as the hanging is to begin at the window on each side, that edge which is cut close for one side must not be cut close for the other. This point being decided, unroll a yard or two of one of the pieces of paper, cut the edge, unroll a yard or two more, roll up loosely the part that is cut, and continue till the end is reached, when the process being repeated with the other edge, the piece will be at last rolled up again as it was at starting. Not more than about ¼ inch of paper should be left at the edge which is not cut close. If there is a back and a front window in the room, the same rule must be observed, and the finish will come in the corner most out of sight, by the mantelpiece, or at the back of the folding doors.

When the edges are finished, the paper is to be cut into lengths, about ½ inch longer than the height of the room; but they must be cut so that the second will match the first, and so on. There are certain dots or marks on the edges which show where the match is, and if the length required comes between these dots, the portion down to the next dot must be cut off after each length, which will bring the match the same as where it started in the first length. Care should be taken to cut straight across, and as many lengths may be cut as will be sufficient for two sides of the room. These are to be turned all together the plain side uppermost, and the first one may be pasted. If the paper is thin and common, it must be put on the wall immediately; but if of good quality, it is to be left to soak for two or three minutes, while for a stiff glazed or flock paper, from five to eight minutes would not be too much. The reason is, to give time for both sides to become equally damp, otherwise there is no certainty that the paper will stick. The first length is to be put up with the close-cut edge close to the woodwork round the window. Having brought the top to meet the ceiling, see that the length hangs straight, trying it if necessary by a plumb-line, then taking it by the lower end, lift it away from the wall all but about 3 inches at the top, then let it fall, and it will drop into its place without a wrinkle. Now with a soft clean cloth begin at the top and press the paper to the wall all down the centre to the bottom, then beginning from the top again, press it from the centre to each side alternately, regularly downwards. If this operation be properly done, the length will be perfectly close to the wall and smooth in every part. It is not to be pressed heavily; but the cloth being taken in the hand as a round loose lump, must be moved quickly over the surface—dab—dab—dab—with a light and clean touch, otherwise some of the colours will be apt to smear. Last of all, mark with the end of the scissors where the paper meets the skirting, cut off all that is over, and press the end carefully into its place. Proceed with the second length in the same way, bringing the close-cut edge to meet the pattern of the first one, and taking care that no gap is left between. Neglect of these precautions will convert a handsome paper into a sight that will be a constant eyesore. Try the lengths frequently with the plumb-line to avoid the chance of getting out of upright, and remember that the outside end of the piece is always the top of the paper.

Paste is best made with old flour, water, and a little size or glue; alum is also added to paste to make it spread more freely without losing any of its tenacity or sticking quality; it should never be used while warm. The paste should be rather thicker than ordinary gruel, and laid on smoothly and equally, not putting too much, or it will squeeze out at the edges. Where this takes place, it must be removed with a clean damp sponge: any accidental smears of paste may be removed in this way, if taken off lightly as soon as they are made. Decorative paper for covering the walls of rooms is manufactured in "pieces," which are 12 yards long and 20 inches wide.

PAPIER-MÂCHÉ.

Two modes of making articles of papier-mâché are adopted, either by gluing or pasting different thicknesses of paper together, or by mixing the substance of the paper into a pulp, and pressing it into moulds. (*a*) The first mode is adopted principally for those articles, such as trays, in which a tolerably plain and flat surface is to be produced. Common millboard, such as forms the covers of books, may give some idea of this sort of manufacture. Sheets of strong paper are glued together, and then so powerfully pressed that the different strata of paper become as one. Slight curvatures may be given to such pasteboard when damp, by the use of presses and moulds. Articles such as snuff-boxes are made by gluing pieces of paper cut to the size of the top, bottom, and sides, one on another, round a frame or mould, which is afterwards removed.

Articles made of pasteboard have a fine black polish imparted to them in the following manner:—After being done over with a mixture of size and lampblack, they receive a coating of a peculiar varnish. Turpentine is boiled down until it becomes black; and three times as much amber in fine powder is sprinkled upon it, with the addition of spirit or oil of turpentine. When the amber is melted, some sarcocolla and more spirit of turpentine are added, and the whole is well stirred. After being strained, this varnish is mixed with ivory-black and applied in a hot room, on the papier mâché articles, which are then placed in a heated oven. Two or three coatings of the black varnish will produce a durable and glossy surface, impervious to water.

(*b*) Papier-mâché, properly so called, is that which is pressed into moulds in the state of a pulp. This pulp is generally made of cuttings of coarse paper boiled in water, and beaten in a mortar till they assume the consistence of a paste, which is boiled in a solution of gum arabic or of size, to give it tenacity. The moulds are carved in the usual way, and oiled, and a pulp is poured into them, a counter-mould being employed to make the cast nothing more than a crust or shell, as in plaster casts. In some manufactories, instead of using cuttings of made paper, the pulp employed by the paper-maker is, after some further treatment, poured into the moulds to produce papier-mâché ornaments.

Uses.—It has now, in some cases, superseded the carved and composition ornaments employed to decorate picture and glass frames; but it is in the ceilings and walls of rooms and the interiors of public buildings that papier-mâché is found most valuable. Plaster and composition ornaments are ponderous; carved ornaments are costly; but those of papier-mâché are light and of moderate price. Maps in relief are also occasionally made of papier-mâché. Paper roofs have been occasionally used. Sheets of stout paper are dipped in a mixture of tar and pitch, dried, nailed on in the manner of slates, and then tarred again; this roof is waterproof, but unfortunately very combustible.

Paper Casts from the Antique.—This method of obtaining facsimiles of sculpture in basso-relievo is very easy. Stiff, unsized, common white paper is best adapted for the purpose. It should be well damped; and, when applied to sculpture still retaining its colour, not to injure the latter, care should be taken that the side of the paper placed on the figures be dry—that is, not the side which has been sponged. The paper, when applied to the sculpture, should be evenly patted with a napkin folded rather stiffly; and, if any part of the figures or hieroglyphics be in intaglio or elaborately worked, it is better to press the paper over that part with the finger. Five minutes is quite sufficient time to make a cast of this description; when taken off the wall, it should be laid on the ground or sand to dry.

Composition for Picture Frames.—Mixing.—The principal ingredients are glue, water, linseed oil, rosin, and whiting, which are combined in such proportions as to make a mixture soft enough for working, while, at the same time, it should be so tough as not to crack, and should harden in a few hours if the ornament be thin, or in a day or two if it be more massive. The state in which it is used by the ornament maker is that of a stiff dough; and the making of it resembles the process by which the baker makes his dough. The proper amount of glue is steeped in water, which is heated to dissolve the glue; while the oil and rosin are melted in a separate vessel, and then poured into the vessel containing the melted glue. The whiting is pounded, and placed in a tub or pan—being previously warmed if the weather be damp and cold—and the hot melted glue, oil, and rosin are poured upon the whiting, and then well mixed up with it, and kneaded, rolled, and beaten until it becomes a smooth, tough, elastic kind of dough or putty. It may then either be used at once, or may be laid aside for future use; but, whenever it is used, it must be warmed, either before a fire or by admitting steam to act upon it, because, when cold, it is too hard and stiff for use.

Moulding.—The manner of using this composition is to press it into moulds; the preparation of which is the most important part of the business; it is generally done by men who are not engaged in making the ornaments themselves. The moulds are usually made of boxwood, which, by its smoothness of grain, permits very fine figures to be cut in it, and is very durable. The mould carver has to proceed with his work in an opposite way to the ordinary carver; for he must make depressions or hollows instead of raised projections, and projections instead of hollows. The mould carver makes his mould look, in every part, directly the reverse of what he wishes the ornament to appear.

Carved Moulds.—The block of wood being planed and smoothed, the carver draws on its surface a representation of the object which he wishes to carve, and then proceeds to work out the minute details. The tools used in this carving are exceedingly fine and sharp, some of them not exceeding $\frac{1}{20}$ inch in width. These are, as in common carving, mostly gouges, with various degrees of curvature. The sharpening of them is a matter of great nicety, and in some cases requires files made of very fine wire. The block of boxwood is moistened with oil during the process of cutting, in order to facilitate the progress of the tool. The cuts are, in the first instance, made perpendicularly from the surface of the wood, and afterwards varied into the necessary directions to produce the pattern. In order to know how to vary the depth of different parts of the mould, the carver must either be guided by the accuracy of his eye and the correctness of his taste, or he must have another mould of the same pattern before him.

Cast Moulds.—Sometimes moulds are made by casting, the material being brass, copper, pewter, lead, or sulphur. A model, representing the object which it is desired to produce, is made of composition or plaster, and is placed on a flat stone, and surrounded by a raised border or edging, so that it lies in a cell or trough. The model is then oiled, and the melted metal or sulphur is poured on it, so as to entirely cover it. When cold, the raised border is broken away, the mould is taken up, and the model is removed from within it. It is then imbedded in a wooden case to preserve it from injury, and to fit it for the better reception of the composition. Sometimes brass moulds are made in this way, and afterwards chased; that is, the minuter details of ornament are cut, or rather scratched, by very fine tools. When the mould, whether of wood, metal, or sulphur, is to be employed to cast ornaments, it is brushed over with oil, to prevent the adhesion of the composition. A piece of composition, large enough for the intended purpose, is then taken up in a warm soft state, and pressed into the mould by the hand. A wet board is laid upon the surface of the composition, and the whole is put into a powerful screw-press, by which the composition is pressed into every part of the mould, however deep and minute it may be. The same pressure makes the upper surface of the composition adhere to the wetted board, so that, when it is taken out of the press, the mould may be pulled off the ornament, leaving the latter adhering to the board. When the cast has become a little hardened, it is cut, or rather sliced off, with a broad knife, to the required thickness.

Fixing.—The composition ornament, thus made, is exceedingly pliant and supple, and may be bent into almost any form without breaking or injuring it; it is this property which makes these ornaments so convenient; as they may be applied to the round, the flat, or the hollow parts of a frame, with almost equal ease. They are fixed on either with glue, or, if quite soft and warm, with hot water, which, by softening the glue contained in the composition, produces a sufficiently strong cement; and, in a short time, they become sufficiently firm and hard to be handled without injury. In modern frames which are intended to imitate antique carved frames, the manner of laying on the various pieces of ornament requires much care in the workman. If an antique frame, or a drawing from it, is given to the ornament maker to imitate, he must have moulds carved of all the various parts, so that, when united on the frame, the assemblage of composition casts may present a facsimile of the frame. If he wishes to produce a frame which shall possess a general resemblance to old patterns, but without tying himself down to any individual pattern, he has to depend on his taste and judgment, both in the cutting of moulds and in the disposition of the various pieces of ornament on a frame. This composition, being a compact substance, is heavy. In this point carved ornaments have a great superiority over composition; indeed, the heaviness of the latter was one reason which led to the adoption of papier-mâché ornaments. When papier-mâché ornaments are used, they are cast in moulds, resembling those just described. The paper is in the state of a pulp; but there is this difference between the two kinds of ornaments. The pulp is pressed between two moulds, so that the thickness of the ornaments is seldom more than about ¼ inch at any part; thus the ornament is of less weight, and there is a saving of material.

PARCHMENT.

Staining.—Blue.—(*a*) Dissolve verdigris in vinegar, and brush over with the hot solution till it becomes a perfect green, then well brush over with a solution of pearlash, 2 oz. to the pint, until it becomes a good blue.

(*b*) Use the blue stain for wood, viz. copper filings dissolved in aquafortis; the material must be well brushed over with it, and then brushed over with a hot solution of pearlash, same strength as in (*a*), until it assumes a perfectly blue colour.

(*c*) Boil 1 lb. indigo, 2 lb. logwood, and 3 oz. of alum in a gallon of water; brush well over until thoroughly stained.

Red.—(*a*) Boil 1 lb. of Brazil wood and 1 oz. of pearlash in a gallon of water, and while hot brush over the work until of a proper colour. Dissolve 2 oz. of alum in a quart of water, and brush this solution over the above before it dries.

(*b*) Use a cold infusion of archil, and brush well over with a pearlash solution, 2 drams to the quart. (See also ii. 251.)

PAVEMENTS.

Asphalt pavements are laid as follows. A foundation is formed of cement or lime concrete, varying from 6 to 9 inches in thickness, according to the traffic. The mineral rock in its natural state, and without admixture with other ingredients, after being broken into small lumps, is brought to a state of dry powder by subjecting it to considerable heat in revolving ovens; it is then put into iron carts with close-fitting covers, and brought on to the works, taken out, laid over the surface, and whilst hot compressed with heated irons into one homogeneous mass without joints. The finished thickness varies from 2 to 2½ inches, according to the traffic of the place in which it is laid, and it further compresses and consolidates under the traffic. Val de Travers liquid asphalt is laid upon a concrete bed 6 inches thick, the asphalt surface being 1½ inch thick. The rock is first ground to a fine powder, and being then placed in caldrons, from 5 to 7 per cent. of bitumen is added to dissolve it; heat being then applied, it forms into a semi-fluid or mastic state, and when in that condition about 60 per cent. of grit or dry shingle is added to it, and after being thoroughly mixed together, the compound is spread over the concrete in one thickness.

With *Limmer asphalt*, a concrete foundation 9 inches thick is first formed, and the asphalt is used in certain proportions by the judgment of those directing the work; it is broken up and mixed with clean grit or sand of different sizes according to the place in which the pavement is to be laid; a small quantity of bitumen is then added to the materials, which are placed in caldrons on the spot, made liquid by heat, and the compound is run over the surface and smoothed with irons to the proper slopes and curvatures. It is run in two thicknesses, the lower stratum being made with grit of a larger size than that of the upper. The total thickness of the asphalt, when finished, is from 1½ to 2 inches.

Barnett's Liquid Iron Asphalt can be made either of natural or artificial asphalt, mixed with pulverised iron ore or sesquioxide of iron, and a small proportion of mineral tar. The materials are put into a caldron which is brought on to the works, and are made into a liquid state by heat, run over the surface, and smoothed in the same way as the other liquid asphalts mentioned; the thickness usually laid is about 2 inches.

Tar Pavement.—Made by mixing with fine breeze, or small coke, just enough of thick refuse coal-tar to make it somewhat sticky; put a thin layer on the smooth and hardened surface, on this spread a couple of inches of metal, or pebbles, or coarse gravel, then a thin layer of the prepared breeze, covered lightly with fine gravel, and beat or press together. It is cheap, slightly elastic, and durable.

Concrete Pavements.—(*a*) The terraza floors used in Italy at the present day are made in the following manner:—1st coat; a concrete, consisting of common lime ¼, sand and fine gravel ¾, laid 6 inches thick and well beaten with wooden rammers; after two days in that climate, it is sufficiently dry for the next coat. 2nd coat; a terraza, consisting of pounded brick or tile $\frac{1}{6}$, common lime $\frac{2}{6}$, sand $\frac{3}{6}$, of the consistency of mortar, laid 1¼ inch thick, well beaten with a light flat rammer. After two or three days it is hard enough for the next coat. 3rd coat; a similar terraza, but with the grit of broken stones instead of sand in it, laid on like a coat of plaster with a trowel. After this has been laid for one day, a layer of small hard broken stones is pressed into it; these stones should be of some substance that will take a polish, and be of uniform size (they are passed through a gravel screen), about that of a walnut: these being afterwards rubbed to a smooth even surface with some smooth hard stone, form a kind of mosaic-work. The stones are frequently selected by colour, and laid in the third coat to a rough pattern. They should be moistened with oil or water till hard set.

(*b*) Dig the earth out about 8 inches, fill in with coarse gravel and stones, well rammed, and levelled about 5 inches. Mix Portland cement to the consistence of cream and pour over, spreading it with a stiff broom; when hard, mix finer gravel with cement and water, and fill up to within ¾ inch of the surface; when hard, mix clean sharp sand and Portland cement, half-and-half, with water to about the thickness of mortar, and finish, slightly rounding. It should not be walked on for a day or two. Cement must be Portland, and fresh.

PHOTOGRAPHY.

(iv. 343.)

Operating Room.—This should be in an elevated position, the south side entirely closed, the north side being glazed with tolerably thick glass, as free from colour as possible, but preferably of a blue tint, to anything at all approaching green or yellow, as these colours, by neutralising the light, tend to prolong the photographic operations. If possible the length of the room should run from east to west, and the ends be protected from the morning and afternoon sun. A room lighted only from the north side has the softest and most uniform light that can be obtained. Part of the roof may be glassed, and curtains of a bluish colour should be fixed, with an arrangement of cords and pulleys, by which they may easily be adjusted to admit light, or cast a shadow in the required direction. The colours of the wall must be carefully chosen, avoiding red, yellow or green; a bluish grey is the safest, and may be used of several tints to give variety. Movable backgrounds painted in different depths of colour are useful to modify the result of any ill-chosen colours worn by the sitter. Oil colour must be avoided for walls or backgrounds; a mixture of slaked lime, litmus, or lampblack may be employed, varying the quantity of lampblack to give the required shade. In the choice of dress, the sitter must remember that cold colours, such as blue or violet, come out white in photographs, whilst the warm colours, red, orange, or yellow, give various shades of black. Articles of dress with vertical stripes tend to give an appearance of increased height to the portrait. The sitter should assume an easy natural position, avoiding a direct vertical light, which falling on the top of the head gives to dark glossy hair the appearance of greyness, and throws very heavy shadows under the eyes, nose, and chin. The best position is a little back from under the skylight, with the head slightly retiring from the side light. The whole figure is then well illuminated; the deepest shadow on the face will be on the retiring cheek, in a three-quarter view, which is generally the best to take. The partial profile will be clearly defined on the shadowed cheek. The position of the body in relation to the head is a matter of taste. The distance of the figure from the background, and its height on the plate, are points which must be regulated by the artistic skill of the operator. If the sitter is placed several feet in front of the screen, the picture will have greater relief, and the apparent height of a person is much affected by the position of the portrait on the plate. Avoid overcrowding the background with vases, columns, and curtains, or anything which will divert the attention from the principal object; as a rule a plain background is the best, the introduction of superfluous furniture and ornamentation most frequently gives a photograph an unpleasant tone of vulgarity. If the head-rest is used, it must be carefully adapted to the head, which should only lightly press on it. When the position is settled and the focus arranged, the sitter should not alter his attitude, though perfect immobility is unnecessary. When the operator has the plate ready to expose, he should caution the sitter to keep the eyes fixed in one direction, and to remain perfectly steady; he may then uncover the lens. The nearer the camera is brought to the sitter, the longer the exposure; thus the time of exposure may be varied from one second to 300 seconds. As a general rule, for a full-length figure, in summer, the plate should be exposed 20 seconds; a sitting portrait will require 30 seconds. In winter the exposure must be increased in duration one-half.

Dark Room.—During certain parts of the process it is imperative that the operator should work in a room into which not a ray of direct light is admitted. This is usually effected by closing every window but one, and that is carefully obscured by yellow or orange coloured curtains, or calico cloth, or a second window sash may be glazed with dark yellow glass. Lamps or candles, provided with yellow screens, may also be used. The dark room should not be too small, as in it several important operations have to be performed; it should be fitted up with shelves for chemicals, a sink and tap, with a good supply of water, several pails for refuse slops, jugs, and draining stands for the plates. The room should be well ventilated, the door and window being kept open as much as possible when the room is not in use, provided that the weather is not too cold, as an even and tolerably warm temperature is necessary for the proper working of the photographic chemicals. In winter the room must be kept warm; gas or charcoal stoves for this purpose should, however, be avoided. Keep the room as clean and free from dust as possible, and place over the bottles of chemicals small covers of paper, twisted round like an extinguisher, to keep the dust from the necks and stoppers. (See also iv. 403.)

Best Light for Dark Room.—About 200 experiments were performed during six days on the following kinds of glass and combinations thereof:—Ruby red (flashed); orange; green, with faint tint of yellow; green, very deep and pure colour; green cathedral glass, with distinct tint of blue; green cathedral glass, deep green, with very faint tint of yellow; green cathedral glass, with decided tint of yellow; olive-green cathedral glass; brandy-coloured cathedral glass; lemon-yellow cathedral glass; Carbutt's ruby paper; aniline red paper; post-office yellow paper; acme red paint on glass; Winsor and Newton's rose madder on glass, &c. These experiments were performed in groups of seven, in such manner that while the time of exposure, intensity of light, sensitiveness of plate, and strength of developer, as well as the length of development, were exactly equal, the results served not only as standards for comparison, but as checks against possible errors. Exposures were made both to cloudy daylight and to artificial light during times ranging in the first case from half a second to five seconds, and in the second case, from 30 seconds up to five minutes.

The several kinds of glass and combinations were further tested by a very powerful spectroscope.

The subjoined values assigned to the several kinds of glass relate entirely to their ability to intercept those rays of the spectrum capable of affecting a pure bromide of silver gelatine plate, and have no reference to their capacity to transmit rays useful for vision in the dark room, a subject which was considered separately.

Ruby red glass, single thickness, offers but little protection. A plate will be heavily fogged beneath it in half a second of daylight, and in three seconds will be rendered completely black and opaque. The same results will be attained by artificial light (a students' lamp was employed) in from 30 seconds to 2 minutes.

Red glass, two thicknesses. A distinct impression of cloudy daylight will be made through this combination in 1 second, but at the end of 3 seconds will not develope up to more than one-third of complete capacity.

Double red with single orange proved to be slightly better than double red alone.

Red, and especially double red, with green, prevents the passage of both luminous and actinic rays.

Green glass is worse by far than red, and those varieties having a yellowish tint, and especially those having a bluish tint, are perfectly worthless.

Green with orange. If the green is deep and pure, is better than single red, and nearly equal to double thickness of red glass; but if the green glass is off colour by reason of either a bluish or yellowish tint, it is inferior to single red glass.

Double green with single orange proved to be rather better than double red glass, and this held true when one of the pieces was slightly tinted with yellow.

All the varieties of cathedral glass named proved to be absolutely worthless, a result which the spectroscope clearly foretold.

Carbutt's red paper is about equal to single red glass, but is inferior to the orange green combination. This paper doubled is about equal to double red glass, but is then nearly opaque to luminous rays also.

Aniline red, acme red, and rose madder (oil colour) are of no value whatever.

Having found the choice so far as opacity to actinic rays is concerned, to lie between the double red glass and the orange and green, it was ascertained that the latter combination with the green glass doubled was rather better than the double red. To ascertain the relative values of these combinations for practical illumination in the dark room, duplicate windows, glazed in the one case with double red glass, and in the other with orange and double green glass, were made for the dark room, which was then tested by both day and artificial light. The result was decidedly in favour of the double red glass. Printing which could be read easily at a distance of 2 ft. from the light through the double red glass could not be read at all at a distance of 6 in. from the same light through orange and double green glass.

The question then arose whether light sifted through two thicknesses of red glass was really any better than the same amount of light transmitted by a single red glass. To decide this point, light was allowed to pass through a single red glass during *one* minute upon a gelatine plate, and upon another part of the same plate covered by two thicknesses of the same glass the same light was allowed to act *two* minutes. The plate after development showed that two thicknesses of glass had rather more thoroughly obstructed the chemical rays than was effected by the single glass; yet the difference was too slight to be regarded as important. It therefore follows that a dim light, or short exposure to strong light, through single red glass is practically as safe as exposure to the same amount of light after transmission through two thicknesses of red glass.

While, therefore, red light appears to be safer than any other colour having the same value to vision, it is by no means destitute of power to initiate the decomposition of bromide of silver. Indeed, a positive was produced in 2½ minutes by the light of a student lamp, distant 10 in., through two thicknesses of the best ruby glass. On development, the plate was found to be rather over-exposed. Of course the same result could have been obtained in about 1 minute through a single pane of red glass.

The conclusion is therefore forced upon us that up to the present time we have no really safe light for the dark room, and since every ray in the spectrum has been tried, the probability seems to be that we never shall have one. The only practicable method approximating safety is to expose plates in manufacture, handling, and development, as little to any kind of light as possible. Plates can be made, handled, and developed in almost perfect darkness. Of course, a glance at the plate in the various stages of these operations is necessary, but the long continued exposures to which plates are frequently subjected, under the impression that the light is "non-actinic" is a delusion to which is probably due most of the failures in dry-plate photography. The fault does not altogether lie with the operators. On the contrary, many of the plates in the market are hopelessly fogged in the factories, while few, if any, are really as free from this defect as it is possible to make them. (Dr. Garrison.)

For the covering of glass for dark rooms and developing lamps, Dr. Stolze proposes an emulsion made by dissolving 10 parts of nitrate of lead in 100 parts of water. To this solution is added, constantly stirring, either 6 parts of neutral chromate of potash or 4 parts of the bichromate. This emulsion is cooled, chilled, reduced into nodules, and washed. After being liquefied, glass plates can be coated with it in the same manner as ordinary emulsion plates. Such a light acts exceedingly well, and can be used with great safety for the handling and developing of plates. The colour is of a pure yellow, and appears very light to the eye. By giving a thinner or thicker coating, the colour and opacity can be easily regulated. To protect these plates from moisture, it is advisable to coat with a crude collodion to harden them, or a chrome alum bath will do as well; and to prevent cracking or tearing when exposed to the heat of a gas or lamp flame, a little grape sugar is added to the emulsion; this will make the coating pliable.

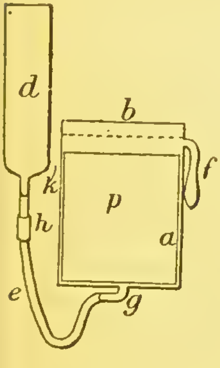
Another method for making red glass

for the dark room was lately given by Cassau, thus: 5 grm. carmine are dissolved in 40 c.c. of ammonia solution; 2 grm. of picric acid are dissolved in 450 c.c. of water, to which 7 grm. of glycerine are added. In this last solution 50 grm. of hard gelatine are allowed to soak 1 hour, and afterward dissolved in the water bath. When the gelatine is thoroughly dissolved, the carmine is added to the mixture. While warm, it is applied to an ordinary sheet of glass or window pane with a wide brush. As soon as the first coat is thoroughly dry, a second or third can be applied until the desired density is arrived at.

Scola has fixed upon the following formula: 100 *c.c.* water, 5 *grm.* gelatine, and 1 *grm.* silver nitrate. Glass coated with this solution is exposed to light until it assumes a reddish brown tint. It is then washed to eliminate the silver nitrate. A surface is thus obtained through which the actinic rays do not pass. The coloration may be deepened by increasing the proportion of silver nitrate up to 3 or even 4 *grm.* Glass tinted in this way may also be used to shade the dark-room lantern.

Developing without a dark-room.—The apparatus consists of a metallic case *a*, (Fig. 51), only slightly larger than the plate for which it is intended, which can be closed light-tight by means of the lid *b*. It is furnished with two tubes, one *g*, entering at the bottom of the bath, which can be connected by a piece of rubber tubing *e*, to the funnel *d*; the other near the top, just above the level of the plate *p*. The former serves to introduce the developer into the bath, and the latter *f* allows the air to escape, and also acts as an overflow.

Fig. 51.



The funnel *d*, and rubber tube *e*, are supported by means of hooks *k*, which fit into an eye. The tubes are so bent that no light can enter the bath. An end view of the bath is shown in Fig. 52, in which a movable hook *i*, fitting into the socket *j*, serves to fix the bath to any convenient support. The film side of the plate *p*, is kept from contact with the side of the bath by means of metallic strips. When the bath is intended for the development of films or paper prints, it is furnished with a carrier (Fig. 53), into which the film or paper is inserted before being put into the bath, and when required for the development of several plates at one time it is constructed with grooves, as in an ordinary plate box.

Fig. 52.

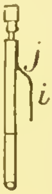
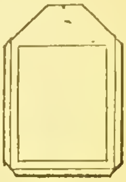


Fig. 53.



The bath is used as follows:—The dark side containing the exposed plate and the bath are placed in a changing bag, into which it is only necessary to insert the hands. The plate is then transferred from the slide to the bath, care being taken to keep the film side toward the back of the bath. After being closed, the bath is withdrawn from the bag into daylight, and fixed vertically to any convenient support by means of the hook. A vessel is placed under the overflow tube, and the inlet tube is attached to the funnel, which, after being filled with the developing solution, is raised and lowered several times to alternately fill and empty the bath, and so ensure the removal of air-bells from the surface of the plate. After standing sufficient time to complete the development, the solution is run off from the bath. The plate is washed by running water through the bath (either by means of the funnel or by attaching the rubber tube direct to a water-tap), after which it is taken out in day-light and "fixed" in a covered tray. If it be desired to "fix" entirely in the dark, the operation may be conducted in the same bath, or in a similar one to which the plate has been transferred in the changing bag. The final washing of the plate may be done either in the bath or in the usual way.

The best developer for use with the dark bath is ferrous oxalate, on account of its property of not producing "fog" even where a plate has been left in it for an hour. It should be made just before use from the following solutions, prepared according to Thomas's formulæ:—No. 1. 300 *grm.* potassium oxalate, 2·2 *grm.* potassium bromide, and water to make 1000 *c.c.* No. 2. 400 *grm.* ferrous sulphate, 3 *c.c.* sulphuric acid, and water to make 1000 *c.c.*

Take 4 parts of No. 1, and 1 part of No. 2, adding 3 parts water.

When the developer is used at once with Thomas's "extra rapid" plates, 12 to 15 minutes in the bath at about 60° F. will suffice to give a satisfactory negative, if the exposure has been correct. The time required to obtain a suitable density is found by placing the exposed plate in the bath, and adding the amount of developer required to fill the bath, in four equal portions, at intervals of 5 minutes. Four densities are thus obtained by developing for 5, 10, 15, and 20 minutes respectively, from which observations the time that gives the desired density is selected. (A. Watt.)

Camera.—This consists of 2 square wooden boxes, the one sliding like a telescope, within the other. On the front of this is screwed an arrangement of lenses, capable of adjustment; and at the other end is a movable screen of ground glass.

Miniature Paper Camera.—It is possible to obtain fair negatives by arranging a sensitive dry plate in one end of a suitable box, while in the centre of the opposite end is a fine needle hole through a thin piece of metal attached to the outer surface of the box. Practically this idea has just been carried out in a small camera recently put upon the market.

The camera bellows is nothing more than a heavy brown-black paper box made in two folds, the whole when fully extended measuring about 3 in. The front portion of the paper bellows is pasted over the edges of a rigid sheet of straw board, cut to the size of the sensitive plate, thereby forming the camera front, and in the centre of this is an aperture about ¼ in. diameter, covered by a film of ruby and green coloured isinglass, pasted on the inner face of the front. A minute needle hole is punctured through the centre of the thin isinglass which forms the lens. The aperture is closed on the outside by a gummed paper flap. Cemented to another straw board, forming the back of the camera, is the sensitive dry plate. The back portion of the paper bellows is then pasted over the back of the camera the same as the front. We then have a light-tight paper box, the front provided with a pin hole and the back with a sensitive plate.

When the folds of the paper bellows are pressed inward, making the front and back come together, the thickness of the package does not exceed ½ in., and measures 3¼ by 4¼ in. An angle of 100° is included in the picture, and the focus is 3 in. It will be seen that its compactness makes it very handy to carry. Several cameras can thus be readily taken in one's pocket, since they occupy scarcely any more space than the sensitive dry plate itself.

In making an exposure, the bellows is extended, and the miniature box is set upon a post, chair, or any convenient support, the front being turned toward the object to be taken. The small wafer of paper covering the aperture is turned down, and an exposure of one to two minutes is given, according to the light. Upon its completion, the wafer cap is turned back over the aperture, and the box is compressed into its original compact form. The plate may be thus packed away for future development. If it is to be developed at once, the box is removed to the dark room, and the back end carrying the sensitive plate is cut off with a knife. The plate is next easily separated from its paper backing, and can be developed in the usual manner with potash and pyro.

The peculiar advantages are that with each plate is furnished its own camera, so that both are always ready for immediate use. No focusing or adjusting is required.

Home-made Camera.—The camera described below is a "best double extension," and has reversing back, swing back, rising, falling, and swinging front, conical bellows, focusing screen with double-jointed hinges. The 15 × 12 extends forwards by rack and pinion to about 30 in. The front is attached to brass supports which, while giving every useful motion, are light, rigid, and handsome in appearance. The camera is of the best design, and, while very portable, is also very firm.

Estimated cost:—

Bellows	£0	18	0
Brass	1	2	0
Wood	0	6	6
Ground glass	0	2	0
	£2	8	6

Beside this, there will be a trifle for glue, screws, and French polish.

Procure the undernoted of well seasoned mahogany:—

4	pieces	17½ × 2½ × ½	Mark them	A
1	„	17½ × 17½ × ½	„ „	B
2	„	17½ × 1½ × ½	„ „	B_2
2	„	17½ × 1½ × ½	„ „	F
2	„	15 × 1½ × ½	„ „	F_2
2	„	17 × 2¾ × ⅜	„ „	R
2	„	17 × ¾ × ⅜	„ „	R_2
2	„	17 × 2 × ⅜	„ „	R_3
1	„	17½ × ¾ × ⅜	„ „	R_4
2	„	17 × 1¼ × ⅜	„ „	FS
2	„	14 × 1½ × ⅜	„ „	FE

This is for the camera focusing frame. For the dark slide will be needed—

2	pieces	31 × 2½ × ½	Mark them	M
4	„	13 × 1¼ × ¼	„ „	S_1
2	„	13 × 4½ × ¼	„ „	S_2
2	„	10 × 13 × ¼	„ „	S_3
2	„	13 × ½ × ⅜	„ „	SH
1	„	14 × 1 × ⅜	„ „	E

In the piece marked S^3 the grain must run the short way of the wood. Take the four pieces A, and having carefully planed them down to measure exactly ⅜ in. thick, dovetail them, and make a bottomless box measuring 16⅝ in. square inside, and 2½ in. deep. The dovetailing must be neatly done, and the box must be exactly square when finished, else the reversing back will not fit accurately. This is important. Those who are not well up to dovetailing had better make a rabbet joint (Fig. 54), and fix it with thin ⅝ in. screws, three in each corner. In putting in the screws, leave the heads projecting very slightly, then file them off flush. This applies to all screws used in the work, as it makes a much more finished-looking job. Next take four pieces ⅜ in. deal and make a square frame to fit tightly inside the box already made. The inside measurement of this frame is 15 in. square. This frame is for fixing the bellows to. Do not fix it in place till reversing back is made.

Fig. 54.

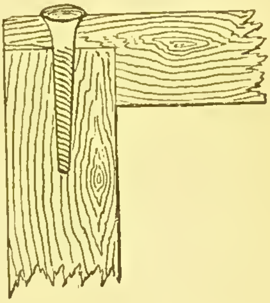
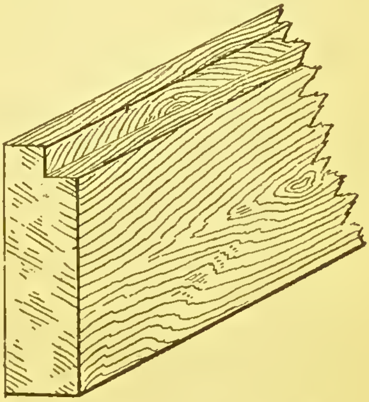


Fig. 55.



In order to make the reversing frame, take the pieces marked R and R 2, make them into a square frame with an ordinary tenon joint, such as the frames of school slates are made with. It must fit rather easily into the body box already made. The inside measurement is 15 by 12 in. (see black lines, Fig. 57). Now take the pieces marked R 3 and dress them, then with an ordinary plough plane that will have about $\frac{1}{8}$ in. feather, run a groove along one side of each (Fig. 55). The groove should be $\frac{1}{8}$ in. deep; if the plough cuts it deeper, plane off the surplus. Should a plough of the exact size not be at hand, a slip of wood can be temporarily glued inside one that is larger to reduce it to the size required ($\frac{1}{8}$ in.) Cut away the feather from one of these pieces, except $1\frac{1}{2}$ in. at each end (Fig. 56). These two pieces must now be screwed down on the frame already made, as shown by the dotted lines in Fig. 57, the distance between them measuring from the top of the feather is $13\frac{1}{2}$ in. The feather is outwards, so as to form a groove with the piece below. R 4 must also be placed as shown (Fig. 57). Do not use glue yet, as they may have to be removed, and do not drive the screws quite home. This finishes the reversing frame except smoothing off, which had better be left till later on. In Fig. 57 the black lines represent the frame made from R and R 2, the dotted lines R 3 and R 4.

Fig. 56.

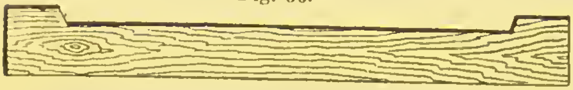
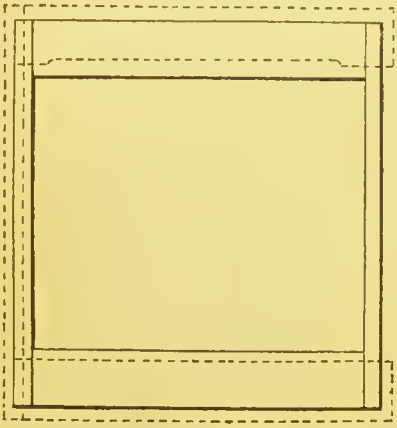


Fig. 57.



In order to attach it to the body of camera, two pieces of brass (Fig. 58) and two clip hinges (Fig. 59) are fixed to the body box as shown in Fig. 60. The edge of the reversing frame is laid into the hooks at the bottom, and the clips at top being shut down hold it fast, at the same time allowing easy removal when required.

Fig. 58.

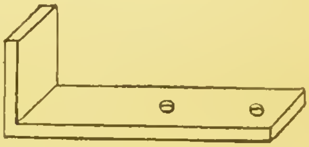


Fig. 59.

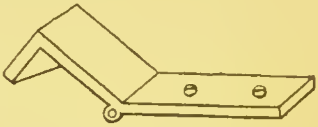
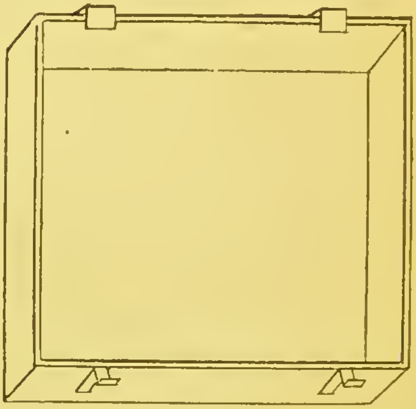


Fig. 60.



Now, with the reversing frame in its place, put the deal frame already made into the body box close up against the reversing frame, and fix it there with screws from the outside. In addition to the wood mentioned, there will be required four pieces 12 by $3\frac{1}{2}$ by $\frac{1}{2}$ in., one piece 7 by 7 by $\frac{1}{4}$ in.; mark them SF. (J. Thomson.)

Lenses.—There are two descriptions of lenses in use. The single lens is used for views and photographs of inanimate subjects. This lens requires a longer exposure of the plate than the double lens, but the resulting photograph is very clear in the details. The compound lens used for portraits consists of two pairs of lenses, mounted in a telescopic brass frame, having diaphragms or stops, and provided with a turnscrew to regulate the focus to a nicety, after it has been roughly obtained by adjusting the camera. The interior of the brass tubes holding the lenses must be kept of a dull black colour; should this wear off, a coating of gum-water and lampblack should be applied when cleansing the lenses. It is important to replace the glasses in the lens in exactly the same order and position, after having removed them to clean, which is to be done with a piece of very soft wash-leather. The single lens is composed of an achromatic lens mounted in a brass tube, fitted with diaphragms or stops of various sizes. These diaphragms are simply flat disks of brass, each having in the centre a circular opening, and upon the size of the opening of the diaphragm used, depends the length of exposure necessary, and the sharpness of the resulting picture. The larger the opening of the stop, the shorter will be the time necessary to expose the plate in the camera; but if a stop be used with a smaller opening, the picture will be sharper and more distinct in the details. Thus, in working with the view or single lens, the operator can choose which point is most material for the particular picture he desires. The plate is of course more rapidly affected in proportion to the brilliancy of the light striking upon it. It is sometimes necessary to use a diaphragm with the compound lens, as for instance in photographs of groups, but the openings in these stops are much larger than those used with the single lens. Portrait lenses are usually provided with central diaphragms.

According to Bausch, the qualities which are involved in a first class photographic objective are as follows: Exact coincidence of visual and chemical foci; a formula involving such glass and curves as will give the utmost freedom from spherical and chromatic aberration; such a relation of glass and curves as will avoid internal reflections and consequent "flare" or "ghost"; length of focus; diameter of lenses; absolute homogeneity of glass, or freedom from striæ or veins; grinding and polishing the various surfaces so that they shall be strictly spherical; absolute centreing of lenses before and after mounting.

We will assume that the optician desires to make a medium-sized objective, of the form which is principally used to-day (a system of two symmetrical combinations), and that he has laid out in advance the formula on which he intends to construct it.

He has in his possession four plates or disks of rough glass, two of which are crown and two flint. If he has any experience at all, he will use no other than such as is warranted by the glass manufacturer, because even then he will find considerable difficulty in obtaining perfect glass. The glass comes from the manufacturer with a guarantee or not; in the latter he assumes no responsibility, while in the former he does as far as the refractive index and most glaring faults are concerned. If they are of guaranteed form, the disks have facets ground and polished on the edges on opposite sides, by means of which the maker has carefully tested the glass and by which means the optician may do the same.

Any variety of crown or flint may be obtained, but the light flints and crowns give the most satisfactory results. Flints are usually the outer lenses of double combinations, and when heavy are exceedingly soft and subject to oxidation. The optician now begins to abrade the glasses, giving them approximately the form he wishes them to have, and then begins the process of grinding and polishing. Although this is done on the same general principle, the details vary with different opticians; and although the same result may be and is accomplished in different manners, it is safe to say that, if one were to follow the plan of another, he would fail. There is a peculiar touch or feeling in doing this work which it takes years of practice to acquire, and even then a person must be adapted to it. Few persons have any conception of the amount of exactness which is required in this work. This remark of course applies mainly to an objective which is to be of the highest standard, and which to a certain extent varies with different opticians according to their skill, and not to such productions as may be called commercial, for the reason that the pecuniary return, and not excellence, is the paramount consideration. A certain amount of care is observed even in the cheapest forms, but these are not subjected to critical tests, and any faults which are not apparent to the purchaser are allowed to pass, which is not the case in the highest grade, where the best is none too good; the result is of course that they are inferior, varying, and unreliable, and while occasionally one may find an excellent lens among them, no reliance can be placed upon them. It has been computed that an error or variation from the spherical surfaces, for instance, so infinitesimally small that there are no mechanical means for determining it, say of $\frac{1}{500000}$ of an inch, will have a noticeable and sometimes disastrous effect in the formation of an image. A first-class photographic objective requires as much perfection as that in the telescope or microscope, and no work spent upon it to accomplish this result is lost.

To return to our objective, we will suppose that all the surfaces have been ground and polished. The difficulty of doing the surfaces increases out of all proportion with the increase in size, as well as the danger of scratching. It is an ordinary event to scratch a surface during the process of grinding and polishing, and nothing uncommon to do so in the last stages of the latter, when the entire work must be repeated. No matter how good a surface may otherwise be, a scratch is inadmissible; not that it does any particular harm, but an optician who takes pride in his work cannot bear it, and the customer who has to pay for it will not accept it. After polishing, the lenses are put into a lathe one by one, and centred, that is, the optical axis is found, which we know we have when on revolution of the spindle the two images which the surface gives are stationary. The edges are now ground down to the diameter of the cell in the mounting.

The next step is cementing. This is a delicate process, for although in each part of the work heat has been used, a much higher degree is required, and the danger of cracking the lenses is increased. It is no ordinary occurrence to lose lenses in this work, or, for that matter, at any point of the process. Great care must here be observed to prevent the cement from turning yellow, thus disturbing the transparency of the lens and causing loss of light. The lenses are next temporarily fixed in the mounting, and are ready to be examined in the camera. Now comes the moment of suspense. Focusing on an object—and for this purpose a large flat screen covered with printed matter containing various sizes of letters, or a large map hung against a perpendicular wall, is the best—the first thing which comes to our notice is the focal length of the objective. It may be one-half of that which was figured upon, or twice as long. However, if not correct, we make note of how much it varies, and proceed to examine the image. This may be sharp and brilliant in the centre, and gradually become more indistinct as it nears the edge, and may remain indistinct near the edges under any amount of focusing; or it may have the same fading out of the image toward the edge when the central portion is sharp, but this may be brought out clear by change of focus; or the image may be such that it cannot be sharply focused at any point. There is yet one possibility, but a strong improbability, that the image may be quite sharply defined over the entire screen; this of course is the most favourable condition.

After making note of whatever the appearance may be, we proceed to determine the coincidence of visual and chemical foci. As is well known, there are, photographically speaking, two sets of light rays emitted by every object. Those that form the image on the screen, and which are most perceptible, or the visual ones, are made up by the red, yellow, and orange colours of the spectrum; whereas those which make the photographed image, or the chemical rays, are formed by blue, green, and indigo, which are the least discernible, and it is a problem of some difficulty to bring both sets to form an image in one plane. To determine this, we proceed to make an exposure on a plate. Before doing this, however, we must be assured of three things: First, that the ground glass is flat; second, that the plate which we intend to use is flat; third, that the plate when exposed will be in exactly the same plane as the ground glass. Upon these points depends a reliable result, and with many plates and cameras these conditions are not fulfilled. If you will go through a package of plates you will find some almost perfectly flat, others that are convex, and others concave, the deviation being fully as much as $\frac{1}{16}$ in., and in larger plates even more.

Ordinarily, and particularly when stops are used, it is of little moment, and it would be almost impossible to furnish selected flat plates at the present prices. The Eastman roll holders are well adapted, because the film passes over a fixed and flat back which remains constant in its relation to the ground glass. If the ground glass is flat, then flat plates should be selected, and if the ground glass be concave, then plates corresponding to it should be used. As a rule, where care is observed, slightly concave ground glass plates are used, because this form favours the lenses. The one thing, however, which should be insisted upon, and which is not always the case, is that the film side of the plate should be exactly in the plane of the ground glass when it replaces it. To determine this the following plan is effective.

Take a straight-edge and allow it to rest upon the face of the frame of the ground glass which rests against the back of the camera. Cut a small wedge of wood, and insert this between the straight-edge and ground glass as far as it will go, and mark the edge in line with the straight-edge, when it fills up the space. Now take a plate which is suited to the plate holder and which is known to be flat, and place it in this, and by the use of the straight-edge and wedge proceed as above with the ground glass. It is unnecessary to say that the marks should agree exactly, and if not, should be made to do so.

These precautions are alike necessary for the optician and photographer, whether for the purpose of determining the quality of the lens, or for making comparisions between several lenses, and it is a test which every camera ought to undergo. After the plate has been exposed and developed, we may find that although we have a sharply defined image on the ground glass, the one on the plate is very indistinct, which shows that the chemical foci may be shorter or longer than the visual. To determine the extent of variation a number of exposures must be made, placing the ground glass within or beyond the visual focus until as sharp an image is obtained in the negative as on the ground glass. We now have all the principal data to enable us to proceed with the correction of the lens. First is the focal length, next is the spherical aberration, then the amount of distortion, and last, but for the present most important, the difference between visual and the chemical focus.

To attempt to correct any one of these qualities will disturb the others, and not only that, they are often to such an extent antagonistic that to improve one will considerably augment another fault. For instance, if the visual and chemical foci do not coincide, it is evident that the objective is chromatically over or under corrected, and if the objective would otherwise give a good image, the inner or cemented surface would probably be changed; this might very naturally affect the focal length, which in a telescope objective would hardly be noticed. The focus of the lens might easily be doubled before the proper correction would be reached, and then changes would again be necessary to bring the focus to the proper distance, which would again disturb the chromatic correction as well as perhaps the spherical, which latter designates the amount of curvature of the image. Thus a change of $\frac{1}{16}$ in. in the radius of one of the inner surfaces, which would hardly be noticed in an ordinary lens, might lengthen or shorten the focus of the photographic objective several inches. The changes which sometimes occur are often surprising and inexplicable, even to one who is accustomed to them. It may be found that the amount of spherical aberration is so great that no amount of changing will bring it to the proper standard. One means of partially overcoming it would be the decrease in the size of the lenses, which would mean that they will admit less light, and consequently be slower.

The thickness of the lens which causes the distortion must be accurately determined. However, we will assume that the various corrections are finally combined as far as is possible, and the skill of the optician must determine to what extent they will be. It may be possible to combine the spherical and chromatic aberrations sufficiently to make the former acceptable, and a new series of experiments will have to be undertaken based on a combination of new glass.

After a lens which meets the ideal of the optician is completed, it may be said, "We can understand that the first lens has involved a great amount of work, but after the completion of the sample none of these difficulties will arise." To a certain extent this is true, but it must be remembered that the optician's work is almost entirely empirical. Each lens is an experiment; there is an individuality in each which cannot be overlooked. A lens is rarely if ever perfect when completed, and each one is a special study. There are certain features which rarely if ever change when working under the same formulas and using the same glass, such as coincidence of visual and chemical foci, centreing, and size, but others, such as homogeneity and refrangibility of glass, sphericity of surfaces, and length of focus are variable, and often can only be reached after repeated trials, and in many instances cannot be obtained at all.

One point of the utmost importance is the sphericity of surfaces. To simply grind and polish a lens is exceedingly simple; to do so and obtain spherical surfaces is extremely difficult. Instead of being spherical, a surface may be and often is a series of elevations and depressions. They may be in the shape of rings, or may be confined to spots or radiate from the centre as pronounced as the spokes in a wheel. Heat, even when moderate, when applied to a certain portion of the lens, causes the same effect. There are optical tests by which you can easily see the expansion of glass after the finger has been allowed to rest upon it for a moment. The same effect may be obtained by fixing the lens in the mounting.

Often lenses are so distorted by the pressure exerted on them in the mounting that it seems almost impossible that they can form even a fair image. What is the effect when these conditions exist? First of all, there is a lack of sharpness over the plate, and then depth of focus. An elevation on the lens will give a shorter focus for all those rays which fall upon it, because of its shorter radius than the focal point for the entire surface; whereas a depression will cause a longer focus, so that instead of all the rays combining in one point there are a series of focal points. When depth of focus is caused by reason of this fault, it is to be condemned, because it is at the sacrifice of definition, and any lens possessing it cannot be rated as good. Depth of focus when caused in this manner is one of the qualities which can be determined without comparative tests, and every lens purchased should be tested to this end. A good means to determine the proper correction of the surfaces is by the use of a diaphragm. Focus for a sharp image on the ground glass by means of a magnifier with a full opening of the lens, and note this point in the camera. Then rack out of focus and insert a diaphragm sufficiently large that the image can just be distinguished, and again focus by means of the magnifier. If the objective is perfectly corrected, this point will coincide with the first, and if not, it is, as stated before, a serious fault, because there will be a different focus for each diaphragm.

Depth of focus and speed are incompatible, inasmuch as both qualities depend on the aperture of lenses, assuming of course a relatively large diaphragm and focal length. While the former decreases with the increase in the aperture, the latter increases. Depth of focus is no doubt a very desirable quality, but to obtain it in a legitimate way with high speed is simply impossible. In two lenses of similar construction, of the same diameter and focus, it will be exactly similar, and the ratio of depth will increase with the decrease of the diaphragm. In view lenses, depth of focus can almost always be obtained by the use of diaphragms, and this is also true in objectives specially made for portraiture; but in these the same is obtained by placing two systems farther apart or varying the distance of the individual lenses, which means nothing more nor less than the production of spherical aberration.

Flatness of field and distortion in lenses are variable quantities, and, although depending to a certain extent on the diameter of lenses, exist to a greater or less degree in one or the other lens, according to the amount of skill and care of the optician. The tendency almost since the first use of lenses has been the increase of speed and consequent increase of aperture of lens, and although the advance has been and is slow to the uninitiated, it means an enormous amount of work to the optician. The actual work of grinding and polishing is comparatively trifling, as is shown in the cheaper form of lenses, where the cost of glass is just as high, but wherein the lenses are used whether good or bad, unless they have faults easily noticed. The time-consuming and worrying work is that of continually testing and correcting the lenses.

As to the homogeneity of glass. A disk should be of the same consistency throughout. When it is not, it possesses either impurities or air bubbles which are usually easily seen, or so-called striæ—which are not so discernible, but of greater importance. These are caused by the unequal consistency of the glass or unequal annealing, and have a similar appearance to a glass of water when strong sugar water is poured into it and is not well mixed, or heated air as it rises from a stove or hot ground. All glass not specially made for optical purposes has them, and can easily be seen by looking through it edgewise, even in the best plate. Of course no disk is used which shows them or air bubbles or impurities on a preliminary examination. They often appear before the lenses are completed, and work then ceases; but very often they cannot be detected until the lenses are finished. Air bubbles can easily be seen by any person; when they exist, the optician must judge whether they are sufficient to impair the saleability of a lens.

If, however, a man who has a reputation to guard permits it to pass, then the purchaser should not be hasty to condemn it, for it then usually possesses merits which far outweigh this disadvantage. Take for instance an air bubble as large as a pin head in an ordinary size lens. Its area is so infinitesimally small as compared with the area of the lens that it is of no account whatever, and does not affect the lens in the least.

Striæ, however, which are difficult to detect, are positively injurious when existing to any extent, inasmuch as they refract the rays passing through them in different directions, thus preventing them from combining to form the image, and they sometimes may cause a false light. They often pervade an entire lens, and occasionally can be seen with the naked eye, but as a rule not. An easy method of looking for the most glaring is as follows: Unscrew the systems and examine each separately. Place one in the camera or on the table in an upright position, and behind it at any distance a lamp or gas jet. Look for the focal point by means of a white paper, and get the eye in the same position, which can easily be done after a little practice. The lens will be found brilliantly illuminated, and the striæ will stand out as dark shadows. When a few small knife edge threads show, they are of little moment; but when in a circle of light there is a wavy appearance, it is generally indicative of other striæ which are injurious, but cannot be determined in this manner.

Definition, distortion, and amount of speed can only be judged by a comparative test or by a person of wide experience. Comparing a lens with one of known excellence is the only reliable manner, but then the following points should be observed. Determine coincidence of visual and chemical foci. Determine coincidence of ground glass and plate in plateholder. Use flat plates when ground glass is flat; if this is not flat, use plates corresponding with it. Determine spherical correction by means of diaphragms.

The two lenses should be for the same size plate, and of about the same aperture and focus. Lenses should always be tested first with full aperture or large stops of the size, as small stops correct spherical aberration in good lenses as well as poor ones. If desired, they can be done with small stops later on. Make comparisons under the same conditions of light. For spherical aberration and distortion, focus on printed matter or on a map fastened to a screen, and have the lens square with the objective and within two or three times the equivalent focus of the lenses, as they are then under the most strained conditions. For depth of focus use stationary objects which have thickness, or a view. Always focus the lens on the same point, and never make a comparison without the use of a magnifying glass for focusing as well as for examining the negatives. Last, but most important, make the comparison in the spirit of arriving at the truth, aud do not permit your judgment to be biased or influenced by your feelings.

Snap-shots.—The following table gives the conditions under which a reasonable degree of sharpness can be ensured without focusing.

To those who are using detective cameras, or taking "snap" shots, the table will be of use, showing the number of feet beyond which everything is in focus when the equivalent focus of the lens and the relative diameter of the stop are known.

Equiv. Focus equals	Stop. $\frac{f}{5}$	Stop. $\frac{f}{10}$	$\frac{f}{15}$	$\frac{f}{20}$	$\frac{f}{25}$	$\frac{f}{30}$	$\frac{f}{40}$	$\frac{f}{50}$	$\frac{f}{60}$
2 in.	7	3½	2¼	2	1½	1¼	1	⅞	¾
2½	10½	5½	3½	3	2⅓	2	1½	1¼	1
3	15	8	5	4	3½	3	2	1¾	1½
4	27	14	9	7	5½	5	3¾.	3	2½
5	46	21	14	11	9	7½	6	4¾	4
6	60	30	20	15½	12½	10½	8	6½	5½
7	82	42	27	21	17	14	10¾	9	7½
8	107	54	36	27	22	19	14	11	10
9	137	68	45	34	28	23	18	14	12
10	167	84	56	42	34	30	21	18	15
11	202	101	67	51	41	37	26	21	18
12	241	121	80	61	49	41	31	25	21
13	283	142	94	71	57	48	37	30	25
14	328	164	109	83	66	56	42	34	29
15	376	189	125	95	76	64	48	39	33

As no two makers number their stops alike, and some do not number them at all, it is desirable to designate their stops in terms of the focal length of the lens. As an example of how misleading is the information obtained by giving the number of the stop, we would refer to the Dallmeyer lenses:—Stop No. 3 in lens 1 A is equal to $\frac{f}{32}$; stop No. 3 in lens 3 D is equal to $\frac{f}{128}$. Here are stops of the same number, in lenses by the same maker, and yet one requires eight times the exposure of the other. The small amount of trouble caused by designating stops in terms of f will be amply repaid by the aid it will give in obtaining correct exposures.

Arranging Lenses in Portrait Combination.—The lenses in a portrait combination are occasionally removed from their cells for the purpose of cleaning. When the lenses are taken out of their cells, they may be variously transposed, and thus rendered incapable of producing good pictures. In a portrait combination there are four lenses in all, the so-called front and back lenses being really each formed of a pair. The front ones are always cemented together, and may thus be easily taken for one lens; the back pair are distinct, and are usually separated from each other by a narrow ring. Take the front lens—the pair cemented together—and observe that one surface is considerably curved, and the other almost flat; place the lens in its cell, so that when screwed into the tube the curved side will be to the sitter. The two glasses forming the back lens are very unlike each other; one is thick at the centre and thin at the edge, the other thick at the edge and thin at the centre; put the thin-edged one first into the cell, resting on the least curved side; next put in the ring, and then the thick-edged glass, concave side towards the other lens; fix them in their places with the part provided, and screw the cell in its place. With many portrait lenses there is an arrangement whereby the front lens may be used as a landscape lens; to use it for this purpose proceed as follows. Unscrew the back lens and lay it aside altogether, as it is only required in the double combination; then remove the brass hood before the front lens; next unscrew the front lens, and rescrew it in the place where the back lens was. In doing this the flat surface will be presented to the object. The lens tube may now be put on the camera, and the central stops will be in their proper place for use. As the focus of the front lens, when thus used singly, is much longer than when used in combination with the back lens, the picture it will yield is proportionately larger, but a much smaller stop must be employed than when the lens is used for portraiture. The exposure must be considerably longer than when the double combination lens is used.

Focus.—An object is said to be in focus when its image is clearly and sharply reflected on the ground-glass screen at the back of the camera. The ground glass usually has the sizes of the various plates marked on it: and having decided what size the picture is to be, move the camera to or from the object until its reflexion occupies the proper position, and is of the size required for the picture. The nearer the camera is to the object the larger will be the picture. The next step is one upon which the chief beauty of the photograph depends, the exact adjustment of the focus, so as to bring out quite clearly those points which are considered essential. Having roughly settled the distance, lay the black focusing cloth on the camera, put your head under it, slide the body of the camera gently in or out, until the reflexion is clearly seen on the ground glass. As different portions of an object are necessarily at varying distances from the camera, some will come into focus earlier than others. In portraits, to make the features show distinctly is generally the chief point aimed at. For views, no rules can be given, but it is advisable to so place the camera and adjust the focus that the photograph shall not distort or confuse the natural lines of perspective. A little practice is required to adjust the focus satisfactorily, as the image reflected on the ground glass is upside down.

Glass Frame.—This is always sold with the camera; it consists of a wooden frame, with two shutters, the one opens on hinges, and allows the plate, which has just been removed from the nitrate of silver bath, to be inserted, with its collodionised face placed towards the sliding shutter, which must be kept closed. The frame is provided at the corners with pieces of wire, which prevent the plate from coming in contact with the sliding shutter. Close and fasten the hinged shutter, and the frame is then ready for use. Remove the ground-glass screen, place the glass frame in its place, with the collodion side towards the object, then on raising the sliding shutter the time must be noted in seconds for the desired exposure. Close the sliding shutter, remove the frame to the dark room, and take out the plate by opening the hinged shutter.

Cleaning the Glasses.—The glasses for photography are sold in certain fixed sizes. When new, the sharp edges must be smoothed over with a corundum file; then carefully wash, rub with a soft rag, finish with chamois leather. When the glasses have been used, they are more difficult to clean. If they have been varnished, they must be soaked in a solution of common soda, or carbonate of potash, till the varnish peels off. If the carbonate of potash or common soda does not bring off the varnish quickly enough, use a solution of an ounce of nitric acid to every half-pint of water. Apply this to the glasses with a piece of cotton wool, fixed on a handle, so as to avoid contact with the nitric acid, which stains the hands. When the plates have been well covered with any of these solutions, let them stand to drain in a rack, then rub and wash well with a sponge and water. Dry. The side intended for the collodion must next be polished with Tripoli powder and a few drops of spirit of wine, rubbed over with cotton wool, wipe off the excess of Tripoli, and polish with a dry chamois leather. Place the cleaned plates into a properly grooved box, with all the faces prepared for the collodion turned one way. It is advisable to wash all glasses as soon as possible after use, as by not doing so the varnishes dry on very firmly, and are difficult to remove. Waste collodion may be utilised for cleaning glasses; it removes all grease. When glasses have once been cleaned, avoid touching them with the naked hand, as it is sure to leave stains. There are various holders in use; the rubber pneumatic is one of the best. Before using a plate, dust it carefully with soft silk or a piece of clean old rag. Perfect cleanliness is imperative.

Sizes of Photographic Glasses.—2½ in. × 2 in., ninth plate; 3¼ × 2¾, sixth; 4¼ × 3¼, quarter, carte de visite; 5 × 4, third; 6½ × 4¾, half; 8½ × 6½, whole. All plates above whole size are denoted by dimensions only, 6¾ in. × 3¼ in. stereoscopic plate. The following are the diameters and focal lengths of lenses suitable for portraits of the usual sizes:—

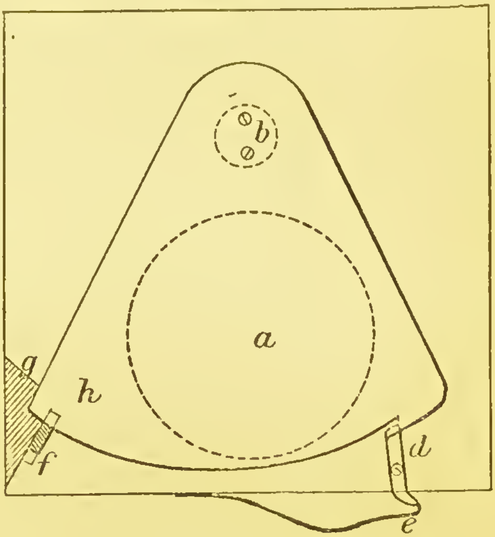
Diam. of Lens.	Focal length.	Size of picture.
in.	in.	in.
1¼	3¼	2½ × 2
2⅜	5	4¼ × 3¼
3¼	7	5 × 4
2⅜	7	6½ × 4¾
3¼	9½	8½ × 6½
For groups:—		
3¼	11	9 × 7
4¼	13	10 × 8
4¾	15	12 × 10
5¼	19	15 × 12
For views:—		
1¾	8	6 × 5
2	10	7 × 6
2⅜	14	9 × 7
3	16	12 × 10
4	24	16 × 12

The dimensions of pictures given are maximum sizes, and to ensure a thoroughly good picture, it is best to use a lens of a larger size than is absolutely necessary. Patent plate glasses are the best for negatives, although flatted crown and sheet glass may be used.

Positives are sometimes taken on deep red or purple coloured glass. Whatever kind of glass is chosen, it should be as flat as possible, otherwise it will be difficult to place in the dark slide.

Shutter.—The shutter to be described can be very easily made, and has some advantages over most shutters. It allows more light to pass through during an exposure. For instance, suppose a shutter is timed to take just one second to open and shut, it is obvious it may open so that at the half-second it is just fully open, and must begin to close immediately; or it may open in one-quarter second and remain fully open for half a second, and close in the remaining quarter-second. This latter will allow more light to pass through than the former. At the same time, it will not allow of more movement than the former, as immediately the shutter is opened a little, an image is shown on the plate, though not so bright as if fully open. It is an important matter in shutter work to get as much light as possible, particularly during dull weather. The shutter has, however, one drawback, and that is a slight kick during the exposure. This, however, is perfectly obviated by having a velvet bag attached to the back of shutter, with a running string to close it round hood of lens. It can then be held in the hand during exposure. With light cameras this is always a good plan; with heavy cameras the slight shake would not be noticed.

Fig. 61.



The outside square in Fig. 61 is of wood $\frac{1}{4}$ in. thick; any wood will do. Two holes must be cut—*a*, of any size to suit lens, and *b* large enough to allow the spindle of hard wood to revolve with the vulcanite flap. At the back of this spindle is fastened a watch-spring:—in such a way that, when the vulcanite is twisted round, it will spring back again in the direction of the arrow. *d* is a catch hinged as shown, and held in position by the spring *e*. The pneumatic release can be inserted between *e* and the bottom of shutter. The dot at the side of *d* is a pin inserted to prevent *d* from spinning round and interfering with the flap in shutting. *f* is a piece of brass projecting through the wood from the back, having a weak spring, making it press upon the edge of the vulcanite, so that when the vulcanite has passed it will come forward into the space dotted at *n*. This is the stop that prevents the vulcanite from doing more than one revolution. The side of the vulcanite at the side of *d* must be shorter than at *h*, measuring from the centre *b*, so that it will clear *f* in passing. The shock of the vulcanite striking *f* is very liable to split the wood; it is better to have a piece of brass *g* flush with the wood and turned over at the side and screwed. A piece of sheet vulcanite $\frac{1}{16}$ in. thick will do for the revolving piece. The more times the shutter is turned round, the greater will be its speed, as the spring at the back will be wound up. It will be seen that the hole *a* is fully open during the greater part of the time taken in completing one revolution. The lighting of the plate is very uniform with this shutter.—(G. G. P.) (See also iv. 424.)

Chemicals.—Among the many chemicals used in photography, the alkaline salts are the most important, and often contain the greatest quantity of impurities. A number of these impurities are incidental to the processes by which the salts are manufactured, and not being easily eliminated in the course of purification, they may cause very serious trouble when used for photographic purposes. Taking sodium carbonate as the first, and, perhaps, most useful alkaline salt in the process of development, let us stop a moment to consider the several processes by which it is made, and the impurities it is likely to contain.

There are three processes from which the sodium carbonate of the American market may be obtained. The first of these is the old Leblanc process; the second, the Solvay or ammonia-soda process; and third, the cryolite process of the Pennsylvania Salt Company. It is probable that most of the soda crystals are made from products produced by the Leblanc soda process. Without going into details, this process consists in first converting sodium chloride (common salt) into sodium sulphate by the aid of sulphuric aid; then by roasting this sodium sulphate with coal and limestone, the sulphate is converted into sodium carbonate ("crude soda ash," as it is called); this last product after crystallising gives us the soda crystals of commerce. The sources of the impurities in this method of manufacture are numerous. The common salt used for the purpose is reasonably pure; at least, the impurities are generally only lime and magnesium salts, which do no harm so far as photography is concerned. But as soon as the sulphuric acid is added, we begin to introduce a number of impurities. This acid often contains arsenic and nitrous compounds, which, when brought into contact with the sodium chloride, form compounds with it that are by no means easily eliminated from the subsequent products. When we remember the exceedingly minute quantities of material that affect the photographic image, we are constrained to believe that the traces of arsenic often found in soda crystals may have some important effect upon photographic results. Yet the quantity of arsenic is exceedingly small in even the crude soda crystals, and possibly its presence is unimportant; nevertheless, it is very active in its reactions, and may have an influence far exceeding our expectations. But this is not the most important impurity in soda crystals. The most serious trouble comes from the impurities introduced during the conversion of the sodium sulphate into carbonate by roasting with coal and limestone. Having made this roasting, the crude semi-fused mass is treated with water, which dissolves the sodium carbonate formed, and gives the liquors from which the sodium carbonate crystals are ultimately obtained. An examination of these liquors reveals the fact that in addition to the sodium carbonate which they contain, there is also present sulphite, hyposulphite, sulphide, and cyanide of sodium. It is obvious that unless the sodium carbonate is crystallised several times, traces of all these compounds find their way into the crystals. Their effect upon the photographic work done with such crystals is the more dangerous, according to their amount.

It is too true that much crude soda crystals in use contains considerable quantities of sodium sulphate. This impurity is harmless, but is an index of imperfect purification, and such crystals should not be used for photographic purposes. If one impurity is present in large amount, it is reasonable to suppose that others of more importance, and not easily eliminated, are also present.

Fortunately, we are not confined to the use of soda crystals, and there are two products in the market that are admirably fitted for photographic use. Only they must be used with judgment. These products are the sodium carbonate made from cryolite, and a like product made from common salt by the ammonia process.

The first of these is perhaps the purest commercial sodium carbonate made, its only impurities being traces of alumina and lime. In using it remember that it is dry sodium carbonate without any water of crystallisation; consequently only about 37 per cent. of the weight given for the crystals should be used.

The sodium carbonate made by the ammonia process is perfectly free from the dangerous impurities incidental to the Leblanc process; but it contains two products that result from its method of manufacture. One of these is ammonia salts, and the other is an excess of carbonic acid. Dry sodium carbonate made by the ammonia process often gives a faint odour of ammonia, due to the volatilisation of the ammonic carbonate which it contains. The presence of the excess of carbonic acid in this last variety of sodium carbonate is due to the imperfect heating of the sodium bicarbonate, which is one of the steps in the process of manufacture. There is no particular harmful influence exerted by this excess of carbonic acid, but it makes it very difficult to determine the true strength of the material. It is almost impossible to know how much real sodium carbonate there is in such a product, the sodium bicarbonate being of little use as a developing agent.—(*Anthony's Photo. Bulletin.*)

Argentometer.—This very useful instrument is for ascertaining the strength of the silver nitrate solution, which becomes weakened to a certain extent, after the immersion of every plate. To use the argentometer, fill the glass jar to within about 2 in. of the top with the liquid to be tested, and then insert it; the degree on the scale that floats on a level with the surface of the fluid will indicate the number of grains of silver nitrate contained in each ounce of the solution. There must be sufficient liquid to prevent the argentometer resting on the bottom of the jar. For strengthening a bath to the required standard, it is generally found more convenient to have a stronger prepared bath to add to the weak one, than to add the silver nitrate direct.

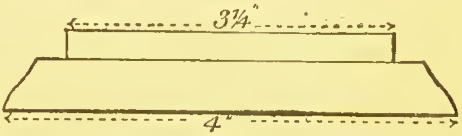
Effects of Weather and Temperature.—During an easterly wind, double or treble the exposure is necessary in outdoor work. The windows of the dark room will require to be re-yellowed in the spring; chemical darkness sufficient in the winter sun will be insufficient in spring and summer. An even temperature should be kept in the studio all the year round; in cold weather all the operations are tediously prolonged, unless the rooms are artificially warmed.

Artificial Light.—Negatives may be obtained by the aid of light given by burning magnesium wire, care being taken that the direct light does not fall on the lens, and that the object is well illuminated. Transparent positives on glass may be printed by the light of a gas-burner, or of an argand oil lamp.

The annexed figures show a cheap and simple magnesium lamp for printing lantern transparencies by contact. It consists of three parts:—Base, shade, and clip (to hold the magnesium.)

Fig. 62 shows section of base with dimensions in inches marked. It is made of wood, and turned circular in the lathe.

Fig. 62.



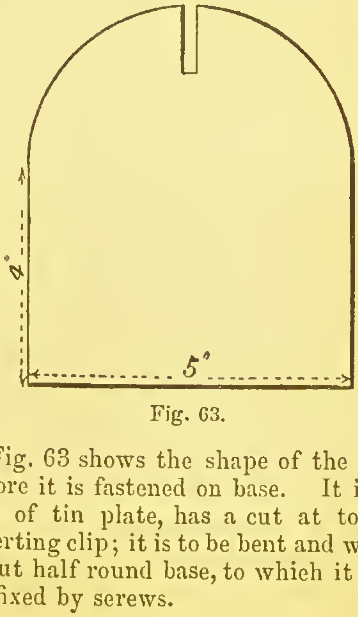


Fig. 63.

Fig. 63 shows the shape of the shade before it is fastened on base. It is cut out of tin plate, has a cut at top for inserting clip; it is to be bent and will go about half round base, to which it must be fixed by screws.

Fig. 64 shows clip in two parts; one is made of brass wire bent in the form shown, and the other is made of a piece of sheet brass about $\frac{1}{10}$ in. wide.

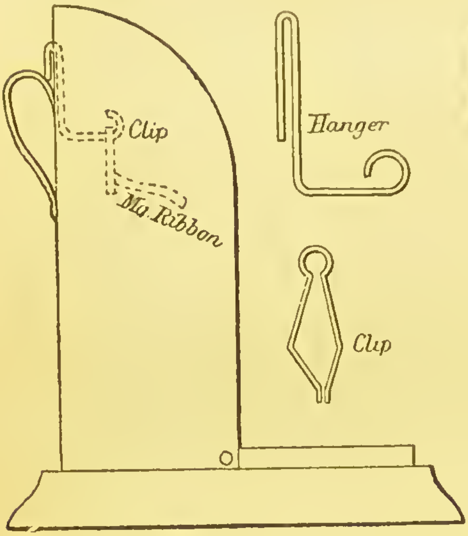


Fig. 65. Fig. 64.

Fig. 65 shows the lamp complete, with the handle soldered on. The position of the clip inside the shade is shown by dotted lines. If the back of the shade be painted black, and a small saucer or tin tray be placed on the base to catch the ashes, it will be everything that can be desired. (A. P. Wire.)

The use of "Photo-powders"—that is explosive light-producing mixtures, the basis of which is magnesium—has more than doubled the field of activity of instantaneous photography. But there is very great inconvenience, even danger, on account of the explosiveness of the substances which enter into the composition of these powders; then, too, there is the irritating action (on the lungs) of the clouds of smoke produced by combustion in the confined atmosphere of a room. The direct combustion of magnesium powder projected into a flame does away with these inconveniences.

The apparatus described below is extremely simple, small, and portable, easy to construct and to use, a vast improvement on the cumbrous and costly arrangements which have hitherto been in vogue.

A small tube about 3 in. long and $\frac{1}{8}$ in. in calibre, twisted like a huntsman's horn, constitutes the whole apparatus (vide Figs. 66 and 67). At one of the ends, slightly widened, a small quantity of the powder is introduced. 2 *grm.* (a quantity which can roughly be judged by means of two marks graven on the tube) will produce a light amply sufficient at a distance of 3 yards for an object-glass of $\frac{3}{8}$ in. aperature and 3 in. focal length. At the opposite end of the tube is a small rubber bulb, such as is used for ejecting a liquid from a bottle in the form of spray.

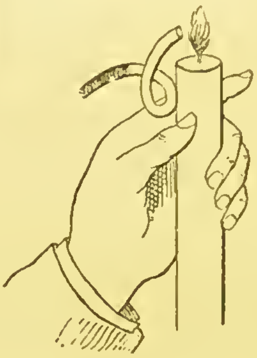


Fig. 66.

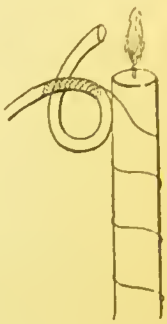


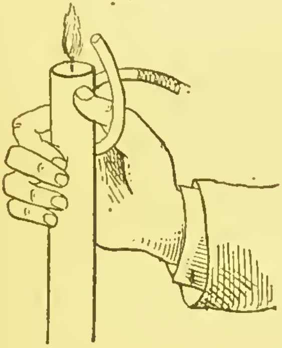
Fig. 67.

The ring of the tube is simply passed over the index finger, as in Fig. 66, or over the thumb, as in Fig. 68, the hand holding a lighted candle. Thus, the open end of the tube is presented obliquely to the largest part of the flame. All that is necessary now is to squeeze with the free hand the rubber ball, when the powder is projected into the candle-flame. A flash is produced instantaneously, which gives a light, rich in actinic power, sufficiently strong for the purpose of photography.

Other forms of attaching the tube to the candle can readily be devised—e. g. Fig. 67 shows the use of a coiled wire, thus leaving the hand free; or the tube itself may be coiled round the candle, or held with a clip, or by any other convenient means which the operator may devise.

The greatest advantage of this arrangement is, perhaps, the certainty and ease with which an operator can illuminate the field at the precise instant he may desire.

Fig. 68.



Again, several of these candles may be arranged in position, the tubes connected with one rubber ball, which places them all under the control of the operator, who can thus produce a number of simultaneous flashes. (See also iv. 398.)

Transparent Positives.—These are taken from negatives, and may be obtained of the same size, or larger, or smaller than the original, as desired. For copies of the same size as the negative, the operation can be effected by placing the negative in a printing frame, in contact with an ordinary dry collodion plate. The negative used should be very clear in the lights, and have transparent shades. To obtain a good negative for this process, use a more acid silver nitrate bath than for ordinary negatives, and do not continue the development so long. By daylight, the exposure required will be a few seconds, but gaslight may also be used, when the exposure must be extended over several minutes. In developing, pyrogallic and citric acid give a blue-black tint; pyrogallic and acetic acid a brown-black tint. If intended to be hung up as a transparency, varnish and protect the collodion side with a ground-glass backing; bind round the edges to keep out dust. If the transparency is required of a different size to the negative, the camera and lens must be used. One means of doing this is to work in a dark room, allow the light to enter through the negative only, and proceed as usual with the exposure and developing. (See also iv. 384.)

Copying Camera.—This is a kind of double-bodied camera, one part of which is provided with holders for the negatives, and has no lens; the other portion has a lens which can be moved so as to approach or recede from the negative, and has the usual ground-glass plate. The negative must be placed in its holder, screw on the lens, and adjust the lens to its proper distance from the negative. If the copy is wished to be larger than the negative, approach the lens to it, and farther from the ground glass; if it is required to be smaller, remove the negative farther from the lens. The light passing through the negative will show its image on the ground glass in the usual way. When the desired size is obtained, remove the ground glass, and replace by a frame having an ordinary wet sensitised plate. Use a diaphragm, with a small stop, and proceed as if for an ordinary negative. It is necessary sometimes, when considerable enlargements are required, to use a camera with a long body opening out like an accordion; the operations are similar when once the proper focal distances have been adjusted. The power of a lens is determined by its shape and diameter. The larger it is in diameter, the more light it will admit; whilst the degree of curvature it has regulates its focal length, and determines the size of the image it will produce. It is the focal length of a lens, and not its diameter, which regulates the size of the image; and the distance it has to be from the ground glass screen determines the length of body required in the copying camera.

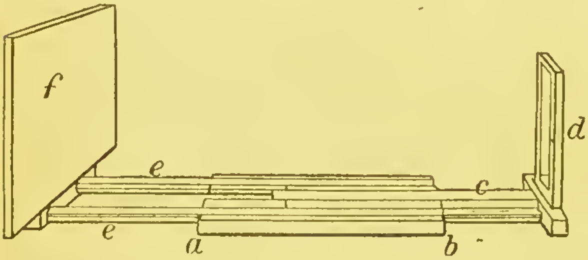
Calculating Length of Camera required.—Calculate the distance the ground glass must be from the back lens, thus: multiply the focal length of the lens used by the number of times of enlargement required, add the focal length to the product. The focus of a quarter-plate lens is generally 6 in.

Say the negative is to be enlarged 3 times, 6 × 3 = 18 + 6 in. focal length = 24 in., the distance required between the ground glass and the lens. The distance the negative is to be in front of the lens is always more than the focal length, but less than twice the focal length.

Enlarging Negatives.—The negative to be enlarged must be absolutely perfect as regards definition, slightly dense, and full of detail, possessing as little granularity as possible. From the negative, either by contact printing on a dry plate, or copied by the wet process in camera, a transparency should be obtained, the development to be effected by the application of a weak solution of pyrogallic acid, to which a few drops of an acid solution of silver nitrate, 10 gr. to the oz., has been added. The contrasts should not be too decided, nor the shadows too dense. From such transparency the enlargement may be produced by the usual studio process up to six or eight diameters without any visible diminution in the excellency of its definition; or the transparency may be enlarged to the required size at once, and a negative obtained from it on a dry plate as before, or upon carbon tissue, each of which possesses its advantages.

A piece of apparatus for this purpose, which is at once cheaply constructed and easily worked, is shown in Fig. 69.

Fig. 69.

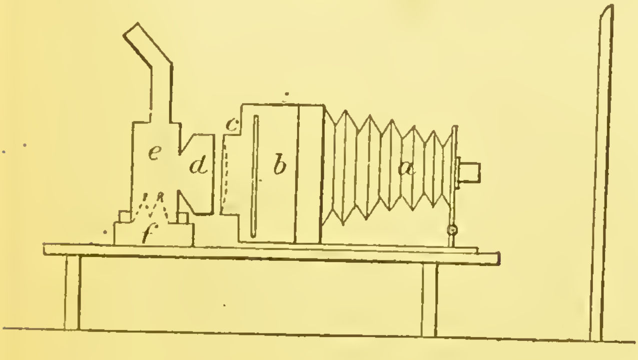


The chief difficulty in making enlargements, when a suitable camera is not available, is in keeping the support for the film, the lens-carrier, and the negative accurately parallel during the process of focusing the image. For this purpose, the apparatus answers admirably:—A base-board *a b* is taken, having a length of about 2 ft., and a thickness of at least 2 in. In this board a wide groove is cut in the centre, in which runs the thinner slab *c*, which carries the upright support *d*. Two narrower grooves are then made on each side of the centre groove, in which run the two square rods *e*, which carry the rectangular support *f*. A glance at Fig. 69, will show that, when closed, the lens-carrier *d*, and the support *f*, are about 2 ft. apart, but that they can be separated, while still keeping parallel, to nearly three times this distance. The size of the board *f* and indeed of the whole apparatus depends upon the size of the enlargement required; but it should, of course, be made to suit the largest size that could possibly be wanted. It is important, also, that the board should be made of sufficiently stout material to prevent any danger of warping. The front *d* is also grooved so as to take the ordinary sliding front of any camera, so that the lens may be raised or lowered as required.

The remainder of the process is very similar to that adopted with an ordinary enlarging camera. A hole is cut in the shutter of the window of a dark room, and a frame made to take the negative. It is important that the plane of the negative should be parallel with the plane of the shutter. The above-described apparatus is then placed in position before the negative, and a hood of black cloth is arranged so that all the light which passes through the negative can pass only through the lens. There are many ways of contriving this, such as simply nailing one end of the hood to the shutter around the hole, and securing the other end with a rubber band around the lens, taking care to make the hood large enough to keep clear of the negative. Having once got the baseboard of the enlarging apparatus accurately adjusted to the plane of the negative, it may be securely clamped in position, and all further adjustments made by drawing out the lens carrier and the support *f*, to any required length. Focusing can be perfectly well done by this means; but it is, of course, better to finish the focusing by means of a screw, if great accuracy is required. The support *f*, if used for enlargements on paper only, is sufficient without any further arrangements, as the paper can be secured in position by pins. Opals, also, can readily be secured by small nails or drawing-pins. For developing dishes, the cheapest substitute is stout tin, well covered with black enamel, which can easily be renewed when necessary. When enlarging by daylight, fasten a piece of thin tissue-paper behind the negative, and reflect the light upon this by means of a plane mirror, fixed at a suitable angle. By the diffusion of the light by the tissue paper, great uniformity is ensured. The whole apparatus, as above described, can be made by a good carpenter for about 10–12*s.*—(J. Vincent Elsden.)

Following is an economical method of converting the ordinary view camera into an efficient projecting lantern without in any way impairing its usefulness in its more legitimate field of operations. With a suitable lens, it will do the work of the vastly more expensive apparatus devised for the special purpose of projecting enlarged images. The accompanying roughly drawn sketch (Fig. 70) will, in connection with the description, make its construction sufficiently evident to enable the tinsmith to duplicate the apparatus.

Fig. 70.



Referring to Fig. 70, *a* is the camera proper; *b*, *c*, *d*, *e*, and *f* are the attachments devised to convert *a* into a projecting lantern. The form of camera best adapted for this use is one of front focus, having a square and removable reversing frame and a moderately long bellows. A little ingenuity, however, will easily find a means of making the changes necessary to adapt the attachments to other types of cameras. *b* is a wooden box, having the same outside dimensions as the reversing frame, whose place it supplies; it is fitted accurately to the camera back, to which it is fastened in the same manner as the reversing frame. It is, of course, open in front, while to its back is fastened by a flange the circular sheet-iron collar *c*, in which the condensers are inserted. *d* is a sheet-iron cylinder attached to the lamp cover *e*, as shown. In the figure it is represented as detached from *c*, over which it slides when the apparatus is in use. *f* is the lamp, the double or triple wick one in common use in the oil lantern. It may be round or square, and it is covered by the cylindrical body *e*, which is surmounted by a chimney. If preferred, this body can be made large enough to fit over the lamp instead of surmounting it as in the cut. If the latter method be adopted, a flange must be soldered to the top of the lamp, the body being slipped over this flange. It will not be amiss to insert a small piece of ruby glass in the side of the body, to serve the double purpose of giving light, and of allowing the height of the flame to be seen. Ventilation must be provided for by holes punched around the bottom of *e*; light is prevented from escaping through these holes, which need not be very large, by soldering a protector to the base of the body, as shown. This is, of course, pierced with holes, but so spaced as not to come opposite the first series.

In one side of *b* a slot is cut, as shown, to receive the frame in which the negative is placed. To the top and bottom of *b*, on the inside, narrow strips of wood are fastened, forming a groove just the width of the thickness of this frame. The frame is not shown in the cut, as its construction and use are sufficiently plain. It is simply a wooden frame, with central opening of the size of the largest negative likely to be enlarged. The negative fits in a rabbet, and is held in place by small brass buttons. Suitable kits are provided for holding smaller negatives. The condensers should have a diameter somewhat greater than the longest dimension of the largest plate likely to be enlarged. Large condensers of fine glass are expensive, but the cheaper grade can be employed if a sheet of finely-ground glass be mounted between the convex surface of the lenses. A pair of 5 in. condensers will be the most generally useful. It is impossible to give dimensions exactly, as they will vary in individual cases. *b* has the same outside measurements as the camera to which it is to be fitted. It may be 3 to 6 in. deep. *c* will have a diameter corresponding to that of the condensing lenses, and should be about 3 in. deep. The part of *d* which covers *c* should be of the same depth, while that part by which it is connected with *e* need not be more than 2 in. deep. *d* can be telescoped over *c*, to adjust the flame of the lamp to the focus of the condensers. The lamp can be cheaply purchased of any dealer in lanterns. Any lens that will cover the negative can be used; rapid rectilinears of short focus will answer every purpose. Should the draw of the bellows not be sufficient to give the required amplification, the lens can be mounted on the front of a cone-shaped box, fitting into the front of the camera. The frame which carries the negative should, when pushed in, completely fill the slot in *b*, in order to prevent the egress of white light. This is easily effected by fastening thin battens to both sides of the carrier in such a way as to be in contact with the camera side when the carrier is pushed home. If the collar *c* is mounted on a board fitting into a rabbet on the back of *b*, and battens are fastened around *b*, about 1 in. from the back, enlargements can be made by daylight by removing *c* and substituting a wooden frame carrying a ground glass. The camera then assumes the form of the well-known Eastman daylight enlarging camera.—(W. H. Burbank.)

Grained Negatives for Zinc Etching Without a Screen.—This is done by coating the plates with an emulsion containing sulphate of baryta in very fine powder, and well shaken up before coating. Pictures are taken upon these plates and developed and fixed in the usual way, but the image, instead of being smooth and nice, will be covered with myriads of fine pinholes. These negatives are used for printing on the zinc in bitumen, then etched in relief for type blocks. Instead of sulphate of baryta, carbonate of soda, &c., may be used in the emulsion, and, after fixing, immersion in weak acid will develop the pinholes. The bromo-chloride emulsion may be used upon collotype plates, followed by drying them in the oven at a high temperature, exposing under a reversed negative. Develop and ink up as for the paper; pull the transfers upon ordinary lithographic transfer-paper. To obtain a coarser grain, soaking in warm water will develop the reticulation.—(W. T. Wilkinson.)

Retouching Enlarged Negatives.—The following method of retouching enlarged negatives is practised by a well-known photographic firm of Berlin. *Papier végétal* is used for the purpose on account of its fineness and transparency. Two pieces of this paper of the size of the negative are cut out, one of them being mounted on the film side, the other one on the glass side of the negative. For mounting, the paper is at first slightly wetted, so that it will become quite tight after drying on the negative, when it is coated all round with glue, and transferred to the glass. In retouching, the larger portions of the negative which are too transparent are strengthened on the paper pasted on the glass side of the negative with powdered black chalk or plumbago, by means of a leather or paper stump. On the paper mounted on the film side of the negative, the flesh portions are equalised with the brush and Indian ink, bold effects of light being at the same time put in where it seems necessary. It is not at all necessary to work very accurately, since the light produces a softness of effect which could only be equalled by the most laborious retouching of the ordinary kind. The enlarged negative is then printed in the usual manner in the printing frame.—(H. E. Gunther.)

Repairing Broken Negatives.—Place the negative, gelatine side down, on a plate rather larger than the negative. Coat the edges of the fragments with warm Canada balsam; join them together, using strong pressnre. Remove the excess of balsam, then cover the negative with another plate exactly the same size, and previously coated on one side with this varnish: 3 grm. sandarac, 3 grm. mastic in tears, 50 grm. sulphuric ether, 25 grm. benzole (pure). Lift together the three plates, turn them over, remove the large one that has served as a support, scrape off from the gelatine side the balsam that may have exuded, then surround the two plates with strips of gummed paper. Heat slightly the fragments before joining them together. This process will yield a print upon which no trace of breaking is to be seen.

Yellow Stains.—Every photographer is familiar with a yellow stain in the negative, caused by taking the plate from the fixing bath before it is thoroughly fixed. Belitski, the well-known photo-chemist, made some experiments recently to remove this stain, and succeeded very well. A slight stain can often be removed by placing the negative in the following solution: 5 parts alum, 100 parts water, 1 part potassinm bichromate, 2 parts muriatic acid. After several minutes the negative turns yellow all through. It is washed now very thoroughly, exposed to sunlight for several minutes, and developed or blackened with the ordinary iron developer. When the stain is very intense, this remedy will not prove to be of any avail, and only by leaving it for 24 hours in the Lainer acid fixing bath he succeeded in removing the stain, and saving valuable negatives.

Transferring Photographs.—To transfer a print to wood, metal, glass, or even porcelain, it suffices to well clean the object if it is already polished, and to polish it in the contrary case, and then to spread over the surface a light coating of copal varnish. Then apply the toned and fixed print, still wet, and with a squeegee or printers' roller drive away the air-bubbles and excess of varnish; allow to dry for 3–4 hours. Then, rubbing gently with a slightly wet sponge, gradually remove the paper, the albumen film containing the image remaining attached to the glass by the varnish. A second coating of varnish will consolidate the whole. The only defect in this process is that it reverses the images. Those who operate on pellicle, or who practice phototype, and detach the gelatine pellicles, can make a reversed print, which, in this case, the process will correct. In this way it is possible to make very beautiful slides for the lantern, which are then to be painted for this particular application. Engravings may also be transferred in the same manner.

Rapid Dry-Collodion Plates.—Dr. Miethe has been experimenting with Gaedicke's rapid dry-collodion plates, and has published the results, which are of considerable interest. Photographing a well-lighted view, and using a small stop, he exposed for four and two seconds respectively; using a large diaphragm, he took an out-door portrait in one second; copied an oil-painting, with the smallest opening, in four seconds and two seconds. The exposures proved to be: No. 1, over-exposed; 2, abont right; 3, slightly over; 4, over-exposed for the yellows;

5, correctly exposed. Development in all cases was completed with the properly-exposed plates in 30 seconds; with the others, in 40–50. He states that the orthochromatic effect obtained was very remarkable, the colours being reproduced according to their values better than they would have been on a plate treated with argentic erythrosine. The grain of the deposit appears under the microscope to be finer and more regular than that of gelatine plates.

Clearing Collodion.—Collodion, which is often slow in settling and clearing after preparation, may be entirely cleared by shaking it up with clean quartz sand. This carries the flocks and impurities to the bottom with it, and leaves the liquid above entirely clear.

Toning and Fixing Gelatino-Chloride Paper.—Louis Bradfisch, an experienced manufacturer and user of aristotype papers, is convinced that the proper manipulation of these papers is by separate toning and fixing. After washing, he recommends a toning bath of gold chloride, soda acetate, and soda bicarbonate, and, when toning is complete, a combined hardening and fixing bath, which should be freshly prepared every day, and consists of 40 m. of acid soda sulphate solution and 2 oz. powdered alum in 20 oz. of water, to which 2 oz. of hypo are finally added. On immersion in this bath, the prints turn yellow, but assume the proper tone in 5–10 minutes.

Toning Gelatino-Chloride Paper.—The simplest toning bath for gelatino-chloride paper is that proposed by W. K. Burton, as follows:—Soda hyposulphite 3 oz., distilled water 20 oz., gold chloride 6 gr. with the addition of 3 gr. of lead nitrate to preserve the whites. The above bath tones slowly, and does not give the richness produced by the ammonia sulphocyanide formula, but will recommend itself to many on account of its simplicity.

Coating Celluloid Films.—A point of interest to users of celluloid films is that the various makers of these films coat the celluloid on different sides, some makers preferring the matt surface as a support for the sensitive emulsion, and others coating on the polished side. Of course, it behoves the user to familiarise himself with the method followed in the films he uses, as otherwise it will be an easy matter to place it in the holder "wrong side out."

Rain-Stained Negatives.—(*a*) Steep in methylated spirit for half an hour, then dry quickly, and the frilling will almost entirely disappear. (*b*) Wash them in slightly warm water, harden the film with a strong solution of alum, afterwards drying them in front of the fire, and then, while still warm, apply common lubricating oil with a cloth. Make it a rule to thoroughly harden the negatives in alum after development. (*c*) Soak them in water and dry them with a moderately strong heat. Of course, the film must be hardened with alum previous to heating, or else the film will melt.

Preparing and Using Plain Paper.—This paper is not only artistic, but costs little to prepare, both of time and money, and gives the most satisfactory results. By following closely the method given below, no one need go astray in its preparation.

One of the advantages of plain paper is its tendency to reproduce the finest detail, and to retain it during the subsequent toning and fixing. There have been many different formulæ given for its preparation, but after exhausting a number of them, the method given below has given the best results. Let us first consider the things necessary for its preparation.

1st. The Paper.—While any kind of good strong white paper can be used, each giving a result peculiar to itself, it is economy to use the Saxe paper, which is easily procured at any photographic supply house.

2nd. The Sizing.—Almost all formulæ advise gelatine, and while that will give excellent results, albumen gives clearer lights, and is much easier to coat.

Formulæ and manipulations are as follows:—

The Salting Bath.—Albumen, 1 oz.; water, 16 oz. Place in a bottle with some broken glass, and shake vigorously until all the flocculent matter is thoroughly cut up; then add 10 gr. of ammonia chloride to every ounce of solution, and, after shaking well, strain through two thicknesses of fine muslin. This salting bath, although simple, will yield the best results. It will tone quickly and easily with but very little gold. With this bath a beautiful neutral tone can easily be obtained; or, in fact, any tone from a dark sepia to a positive black.

After filtering, pour your solution in a tray large enough for the sheets you intend to coat, being careful to remove all air bubbles. Now immerse the sheet in the solution for one minute, then draw out quickly by two corners and hang up by means of a clip to dry. After it has thoroughly dried, float the right side of the paper on the solution for two minutes.

The paper has a "right" and a "wrong" side, which can easily be distinguished after the first bath by the grain of the paper, the smooth side being the right one to float the second time. Now hang up to dry again in the same manner as before. You can salt any quantity of the paper, as it keeps indefinitely if kept in a dry place.

The sensitising bath should be an ordinary neutral bath, 50 gr. to the ounce, and kept neutral by the addition of soda carbonate; it is prepared as follows:—Take the amount of water that you wish for the bath (about 10 oz.) and add silver nitrate until an "actinometer" shows it to be 50 gr. to the ounce. Neutralise by adding enough of a saturated solution of soda carbonate to form a slight precipitate (about 10 or 15 drops). The precipitate which is produced should be left in the bottle. Shake well, and after the bath has settled it is ready for use. You can either filter or decant the clear solution into your silvering tray.

Float the paper 3 minutes on this solution, using the same precautions as when floating albumen paper, being careful not to get any of the solution on the back of the paper.

It is a good plan to place one end of the paper on the bath first, then lower carefully until the entire sheet is in perfect contact with the bath, this will force any bubbles, should there be any, from under the sheet. While the sheet is in contact, raise the corners separately to see if there are any; if so, they should be broken with the finger or a glass rod.

The sensitising bath should be tested from time to time and kept up to the required strength by the addition of fresh silver nitrate. It will be neutral as long as there is any excess of soda carbonate in the bath.

After sensitising, dry the paper thoroughly, and keep in a dry, dark place. If kept in a perfectly dry state it will last for several days; but when it can be, it should be used at once, to ensure the best results. The sensitising operations may be safely carried on by lamp light.

Printing.—The best results are obtained by fuming the paper for 20 minutes over ammonia, after which expose the same as albumen paper. After fuming, the paper is extremely sensitive, and had better be exposed in diffused light, unless the negative is very dense. It is better to print somewhat deeper than you care to have the finished print, as it loses density during the toning and fixing.

The Toning Bath.—Make up a stock solution as follows:—Water, 7½ oz.; chloride of gold and sodium, 15 gr.

Take ½ oz. of this solution and immerse a piece of litmus paper in it, which will turn red; now add, gradually, enough of a saturated solution of soda bi-carbonate to restore the litmus to its original colour; now to 24 oz. of filtered water add the neutralised gold, and a very small pinch of sodium chloride (common table salt); stir thoroughly, and your bath is ready. For simplicity and excellence this cannot be surpassed.

The quantity given is ample to tone one dozen 5 by 8 prints. It can be strengthened from time to time by adding gold from the stock solution, being careful to neutralise it each time.

After washing the prints in two

changes of water, they are immersed one at a time in the toning bath; a dozen or more can be toned at the same time if you are careful to keep them in motion by changing them during the process of toning. Leave them in this bath until they assume a deep purple; if fixed at this stage, the result will be a warm sepia, which will dry out a neutral tone; do not carry the toning until the prints lose their brilliancy. Generally about 15 minutes is ample, but will vary according to the temperature and amount of gold in the bath.

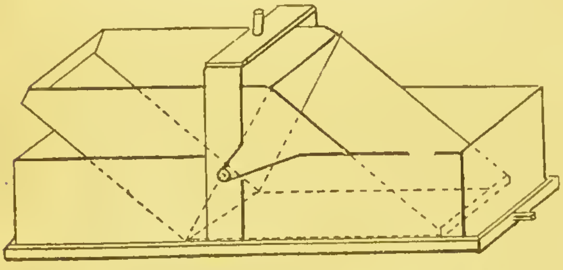
Prints fixed without toning give a very artistic and pretty effect, producing a result not unlike a photogravure in tone and general effect.

The Fixing Bath.—The prints are fixed in soda hyposulphite 1 oz., water 8 oz., for 15 minutes. They should then be washed in running water for two hours.

After drying, trim, then lay them one on the other, and place a heavy weight on them overnight, the next morning the prints will lie perfectly flat. Now procure some heavy, stiff, white paper, and have it cut large enough to allow a good margin when mounted. For example, a 9 × 11 mount for a 5 × 8 print. Mount by simply sticking the corners.—(W. S. Waterbury.)

Automatic Apparatus for Washing Negatives.—Fig. 71 represents an automatic apparatus devised by Gorceix for washing photographic negatives. It consists of two triangular prismatic troughs, placed back to back, oscillating on a rod passing through them a little above their centre of gravity, and supported by two uprights. The oscillation causes the partition common to the two troughs to take two positions, one to the right and the other to the left, that make an angle of about 15° with the vertical. The uprights are fixed to the sides of a box provided with a waste tube, and are connected at their upper part by a cross-piece, that carries a tube through which water continuously enters the troughs. The water, on entering the compartment below, raises the centre of gravity laterally, and when the latter gets above the axis, the troughs tilt. A part of the water is thus emptied into the box, while the rest, being held back by a narrow rim, covers the plate and enters the gelatine.

Fig 71.



As a consequence of the rocking motion, the other trough is brought under the stream of water and becomes full in its turn, and the two troughs then tilt in the opposite direction. These motions continue as long as the water flows, and their frequency depends upon the discharge, which may be regulated at will by means of a cock.

It will be seen that when once operations have begun, the washing proceeds very regularly. The negative soaks for a certain length of time in the water, and gives up to it a portion of the salts that it contains, and then a larger bulk of water dilutes the solution and is in part ejected, so that the strength of the liquid lowers so rapidly that there are soon only inappreciable traces of solids in the water, and the washing is then finished. When it is a question of ridding paper proofs of soda hyposulphite, the troughs are covered with wire cloth with wide meshes, which holds the proofs without interfering with the circulation of the water.

The apparatus is made of zinc covered with bitumen, which is afterward exposed to the sun.

Making Gold and Silver Salts.—The salts of gold and silver used in photography are expensive to buy, and their manufacture is not difficult, even if undertaken by a non-chemical person, if he follow closely the directions about to be given.

There are two chlorides of gold—the protochloride and the terchloride. The latter salt is the one used in photography. The chemical formula of the protochloride is AuCl, and that for the terchloride is $AuCl_3$ (that means that in the terchloride there is three times as much chlorine united with the same amount of gold as that in the protochloride). The terchloride is the most important compound of the metal. It is always produced when gold is dissolved in a mixture of nitric and hydrochloric acids. Gold is not dissolved by any simple acid, nor by any other liquid than this nitro-hydrochloric acid. The deep yellow solution produced by dissolving gold in this compound acid yields by evaporation yellow crystals of the double chloride of gold and hydrogen. When this is cautiously heated, hydrochloric acid is expelled, and the residue on cooling solidifies to a red crystalline mass of terchloride of gold, which is very deliquescent (that is, it imbibes moisture), and is soluble in water, alcohol, and ether. The terchloride combines with a number of metallic chlorides, forming a series of double salts. These compounds are mostly yellow when in crystals, and red when deprived of water. A mixture of terchloride of gold, with excess of bicarbonate of potash or soda, is used for gilding small ornamental articles of copper. These are cleaned by dilute nitric acid, and then boiled in the mixture for some time, by which means they acquire a thin but perfect coating of reduced gold.

The yellow needle-shaped salt usually obtained by evaporating the acid solution to the crystallising point is an acid chloride (formula $HClAuCl_3$). As it is not absolutely necessary that perfect purity of the chloride is essential for photographic purposes, the salt can be made from any scraps of gold ornament of 18 to 22 carats fine. It would not be worth while to employ a lower standard, since the larger amount of alloy in 15, 12, and 9 carat gold would too much interfere with the production of good terchloride; and, moreover, the small amount of gold present would not be of sufficient quantity to repay the trouble of manipulation. If small quantities of the salt be required, a book or two of gold leaf can be employed for its production. If larger quantities, a gold coin may be used.

The atomic weight of gold is 197, and that of chlorine 35·5—that is, 197 parts of gold unite with 35·5 parts of chlorine to form the protochloride (AuCl), and in the terchloride 197 parts of gold unite with 106·5 (i.e. 35·5 × 3) of chlorine to form the auric chloride ($AuCl_3$); consequently, the combining weight of the latter salt is 303·5. The Australian gold coins are alloyed with silver, and therefore are preferable to those of the English mint, inasmuch as the silver is left in the shape of undissolved chloride, which can afterward be filtered out, whereas copper is much more difficult to get rid of.

Conversion of Gold into Terchloride.—Put into a long wine-glass or thin narrow tumbler 2 fl. dr. of nitric acid to 1 oz. of hydrochloric acid—that is, the first acid is in the proportion of 1 to 4 parts of the latter. If the acids are of concentrated strength, a little water will be necessary to add to this mixture of acids; if they are of ordinary strength, water will be unnecessary. Place the glass vessel containing this mixture of acids in a saucer on the hob, so that, should the vessel crack, the liquid will not escape, or else place the vessel in a basin of hot water. The gentle heat afforded from either of these sources should be maintained until the gold is dissolved. Place the coin or scrap gold in the mixed acids, and stand on the hob, so that the fumes given off shall escape up the chimney. The above quantities of acid will generally be sufficient to dissolve a sovereign or its equivalent weight of scrap gold. If, however, the solvent action ceases before the gold is dissolved, add a little more acid. A great excess of acid should be avoided, because it renders their neutralisation or subsequent elimination more difficult. If pure leaf gold be employed, the solution will form a perfectly transparent yellow liquid. In the case of the Australian gold coin, however, the small portion of silver alloyed with the coin will give a precipitate of silver chloride, which will give a cloudy appearance to the liquid. Pour this solution of gold into a basin, and add to it about 6 oz. of distilled water, and stir up the mixture with a glass rod. Next add some powdered chalk to the liquid to neutralise its acidity. The way to ascertain whether the acid is completely neutralised is to dip a piece of blue litmus paper or to drop a little tincture of litmus solution in the acid. If any acid be present, the paper will lose its blue colour, and be coloured pink or red. If the blue colour remains unchanged, then you know the acid is completely neutralised. Stir the chalk well up in the liquid, and then filter it into a bottle thus: Take a piece of clean white blotting paper, cut it into a circular form, fold this in half, and then fold again, so that it forms a quadrant—a quarter of a circle. Open this paper out, and place it in a glass funnel. Just moisten it with a little distilled water, to keep it in its place, and then stand the funnel in the neck of a clean bottle, capable of holding the solution of gold that filters through. The chalk, having united with the acids, will have formed solid salts of lime, which are retained on the filter paper. The liquid solution that passes through is a solution of gold terchloride, fit for use in photography. As light partly reduces the gold into the metallic state, it is best to keep the bottle in the dark, or else closely enveloped in black paper, pasted round it.

To obtain the terchloride in the crystallised state, the above solution must be evaporated until the salt crystallises out in reddish crystals. As these crystals imbibe water if placed in a moist atmosphere, and then form a yellow solution again, they should be stored up in hermetically sealed glass tubes. These tubes are easy of construction, thus: Take a piece of soft glass tubing, about 12 in. long and $\frac{1}{4}$ in. bore; hold one-third of it in the flame of a spirit lamp or gas flame, twirling the tube round, so that it is uniformly heated. When the glass begins to bend, hold it away from the flame, and, holding the tube at both ends, pull them apart, like stretching a piece of elastic. The heated part of the glass will yield to the pull, and, stretching, become narrowed. Break the tube in two at this narrow part, and then hold each of these narrow ends in the flame for a few seconds, until the glass, recoiling on itself, closes the orifice. Put the crystals of terchloride in with a quill at the open end of the tube, and then close that by directing the flame of a blowpipe on the periphery of the orifice until the glass melts and closes the aperture. The stem of a clay tobacco pipe forms a good substitute for a blowpipe.

Silver Nitrate.—The chemical formula for silver nitrate (known to chemists as argentic nitrate) is $AgNO_3$. It is one of the most important salts of silver. It is readily made by dissolving the metal in moderate dilute nitric acid, and concentrating the solution, when it separates out in anhydrous tables belonging to the triclinic system. It dissolves in its own weight of cold water, forming a neutral solution, which is partly reduced by the action of hydrogen with the production of metallic silver to silver nitrite. It is soluble in alcohol and ether. It melts at about 224° F. It rapidly attacks and destroys organic matter, and acts as a violent corrosive poison. It stains the skin, hair, &c., black. The salt blackens when exposed to light, more especially if organic matter of any kind be present. (To prevent this decomposition, the bottles containing the crystals should be covered with paper, as previously directed.)

Pure silver nitrate may be prepared from the metal alloyed with copper—such, for instance, as common silver ornaments not made of pure silver. The alloy is dissolved in nitric acid, the solution is evaporated to dryness, and the mixed nitrates are cautiously heated to fusion. A small portion of the melted mass is removed from time to time for examination. It is dissolved in water, filtered, and ammonia is added to it in excess. While any copper salt remains undecomposed, the liquid will remain blue, but when that no longer happens, the nitrate may be suffered to cool, dissolved in water, and filtered from the insoluble black oxide of copper.

Silver nitrate is sometimes adulterated with potash nitrate, and occasionally contains traces of copper and lead. When precipitated by a slight excess of hydrochloric acid, the filtered solution ought to leave no fixed residue when evaporated on platinum foil, as the whole of the silver would be thrown down, and any impurity would remain in solution. Copper is detected by adding ammonia in excess to the solution, when it will give the liquid a blue tinge.

Production of Silver Nitrate.—$AgNO_3$ (atomic weight equal 170; e. g. atomic weight of Ag is 108; atomic weight of N is 14; atomic weight of O_3 is 48). Silver nitrate can be made from scraps of silver articles of jewelry, for although silver ornaments are made of silver alloyed with another metal—usually copper—yet the silver nitrate can be obtained pure by the processes described below: Since, however, the heat which is necessary to decompose the copper nitrate often produces silver nitrite, it is advisable that silver nearly free from copper should be chosen in preference.

Ordinary commercial silver nitrate is obtained as a by-product in the operations of parting gold and silver, which are carried on in the refineries, and also in many assay processes. The necessary careful attention for the production of a pure nitrate is not always bestowed on it. Too frequently the crystals are sent out simply dried off from the nitric acid; and in other cases, owing to the addition of charcoal to the vessel containing the silver solution, not unfrequently particles of charcoal, oxidised by nitric acid into a body which shows great affinity for the silver, are also present. Consequently, commercial silver nitrate should be purified by recrystallisation. Perhaps the best article to use would be a silver coin.

Preparing Silver Nitrate.—Put a piece of silver into a thin glass beaker or retort, pour on it some pure nitric acid, and support the vessel over a spirit or gas flame. If a beaker is used, an iron wire triangle high enough to reach over the top of the spirit lamp can be used, on which place a piece of iron wire gauze, and then stand the beaker containing the silver and acid on top. (A spirit lamp can be bought for 1*s.*, the triangle for 4*d.*, and the wire gauze for 3*d.*, and can be obtained from or through any dispensing chemist.) If a retort is used, a ring stand should be employed to hold it. Continue heating the acid until the coin is dissolved, and crystals appear. Take these crystals out of the vessel, put them into a saucer, and pour on them a little dilute nitric acid, and then redissolve them in water, and crystallise by evaporating this aqueous liquid. A porcelain evaporating dish is the best article to employ for this purpose, or it may be done in a saucer placed on a shovel held over a fire. If the nitrate is not wanted in crystals, it can be obtained thus: After having dissolved the coin in the nitric acid, boil this impure acid solution until a dry mass is obtained, without becoming crystalline, for which purpose the beaker containing this acid and dissolved silver can be stood in a saucepan containing water, and the water allowed to boil, care being taken that it does not boil over into the beaker. Put this dry mass into a crucible (bought for a few pence) and fuse it pretty strongly. This fusing can be performed in this manner: Make a good, clear coke fire, and stand the crucible in an iron spoon or ladle in the fierce part of the fire, until the fusion is complete. Take out a portion of the fused mass from time to time, dissolve it in water, then filter the solution thus obtained, to free it from copper oxide, and to the filtered solution add a little ammonia. If a blue colour is produced, the fused mass contains copper nitrate still incompletely decomposed. In such case continue the fusion until a portion taken out and treated as just mentioned ceases to give a blue coloration to ammonia. When this occurs, dissolve the fused mass in water, when it is ready for use, or can be recrystallised as already described.

Another process for obtaining silver nitrate from an alloy of copper and silver is to dissolve the alloy in nitric acid and suspend a piece of clean metallic copper until the silver is wholly precipitated. Take out the copper, and wash the silver in plenty of water. This washing is performed by adding water, stirring the precipitated silver salt, and pouring the solution into a filter; then keep adding water to the mass in the filter. Collect the precipitate off the filter paper, and add to it a little solution of silver nitrate to remove any adhering particles of copper. Finally add some nitric acid to the precipitate, and crystallise by evaporation. A third process is to precipitate the silver from the coin by immersion of a piece of copper in the acid solution (as just directed in last experiment); wash the precipitated silver in nitric acid (being careful not to add an excess of acid; if excess has been added, evaporate carefully to dryness to expel it); then to neutralise and remove traces of the copper salt, add silver oxide to the boiling solution (of precipitated silver and nitric acid), and filter it. When the filtrate ceases to give a blue coloration to ammonia, the nitrate may be looked upon as pure. This solution, if of the right strength, might be used at once for photographic purposes.

The purity of silver nitrate may be easily ascertained by dissolving a portion in distilled water, and precipitating the solution entirely with pure hydrochloric acid. The liquid filtered from the precipitate should leave no residue on evaporation to dryness. Taylor, an authority in photographic chemistry, says: "Nitrate of potash and nitrate of copper would have little effect, except in reducing the strengths of the bath. The peculiar photographic action of bad nitrate of silver is probably to be referred to a different source, viz. to the presence of oxidised organic matter. In the assay process" (of obtaining this silver salt) "fragments of charcoal are introduced to prevent the acid from bumping in the vessel as it dissolves the silver. We have good reason for believing that during this process the nitric acid oxidises the charcoal into a substance which has an affinity for the silver salt." And Taylor has found that silver nitrate so produced is altogether unfit for collodion photography. "The fact is certain, that silver nitrate prepared by dissolving silver in nitric acid and evaporating to dryness without any crystallisation cannot be depended on for photography." In this case recrystallisation of such salt should be resorted to for obtaining the nitrate in a fit and pure state. A saturated solution of the purified crystals slowly restores the blue colour of reddened litmus paper if the nitric acid be expelled by heating to 240° F. previous to the second recrystallisation. This proceeding, however, is not actually necessary, inasmuch as a trace of adhering nitric acid can always be removed by soda carbonate when making the bath. The action of light upon silver nitrate is very peculiar. If pure, it may be kept unchanged in the crystallised form, or in solution in distilled water; but if the solution contain vegetable or animal (organic) matter, the nitrate is decomposed and blackens. The stains upon the skin produced by handling silver nitrate are produced in this way, and are seen most evidently when the part has been exposed to light. The varieties of organic matter which especially facilitate the blackening of silver nitrate are such as tend to absorb oxygen.—(H.C.S.)

Taking Portraits Indoors without a Skylight.—Any one who is skilful in outdoor photography can make a better portrait in an ordinary room than can be made in the open air. In fact, there is no reason why as perfect a portrait cannot be made in an ordinary room as in a "gallery," except the lack of skill on the part of the operator.

The first attempt is generally made in the room having the largest number of windows, all of which are opened to their fullest capacity, which only results in complete failure. The room preferable is one on the second floor or higher, and on the light side of the house. Close the blinds or lower the shades in such a way as to exclude the light from all windows but one. This window should be selected in such part of the room as will allow working space on both sides of it. A corner window with the side wall close to it is objectionable, for the reason that a background would be so near to the sitter that a shadow of the figure would be made upon it. Now, having the window open and the shade rolled all the way up, if there is sunlight or even a strong light upon it, darken the lower half by unhanging the shade (if convenient) and placing the roller upon the top of the lower sash. Allow the shade to fall to the sill, or hang anything over the lower sash that will exclude the light. If the subject is of very dark complexion, a piece of muslin would answer better than something opaque, as it would diffuse light over the face in addition to that obtained from above. If the clothing or drapery is very dark, it is well to obstruct the light from the lower sash just opposite the face and let it pass through below, so as to light up from the neck down; this will ensure detail in the drapery. Never allow sunlight to fall upon any part of the sitter. If the sunlight is very strong at the upper part of the window, a piece of cheese cloth or such like material may be placed over it, but not anything heavier. Now place a chair for posing the sitter about 18 in. from the window, and so that the front of the seat is about 1 ft. behind the line of the side of the window; this will bring the knees on a line with the side of the window.

Having seated the person, look at the head, and you will find the light falling strongest on the top, and at an angle of about 45°, i.e. striking the forehead on the side toward the window and passing down toward the lower opposite side of the face, throwing the shadow of the nose upon the side of the upper lip, thus you have the skylight effect. When the eye becomes a little practised, you will know whether a better effect is produced by moving the sitter a little forward or back—a little closer to the window or away from it. If a three-quarter face is to be made, the light may be strongest on the small side of the face by having it turned a little away from the window; this would be a "Rembrandt." If the light is wanted upon the larger side of a three-quarter face, then let it be turned a little toward the window. Always have the eyes looking straight ahead—not to one side. Place the sitter as far back on the seat of the chair as possible, then make a small roll of clothing, or take a thick book and place between the back of the chair and the back of the sitter, behind the shoulder-blades. This will throw the chest and shoulders forward. Don't be deceived by the notion that a person must sit comfortably and "naturally" to make a good portrait. Of course, make him as comfortable as possible under the circumstances. Be sure to have the chin high enough and the line of the face (as shown against the background) perpendicular. Use a head rest or not, as you like. No one likes the sensation of having it against the head. If you are making a three-quarter face, let the body be square with the camera; if a full face, turn the body—preferably toward the window. If a profile, place the chest, shoulder, or even back toward the camera. All this may be varied according to the taste and judgment of the operator. If the side of the face away from the window is too dark (which is almost always the case) place a sheet, or anything white, and about one yard square, in such a way (not nearer than 3 ft.) as to reflect a little light upon this side of the face. The danger is of throwing too much light upon this side, making the face flat, and destroying all contrast. Be careful to have the sheet held or placed in such a manner as not to be reflected in a large white spot upon the eye of the sitter.

The camera should, of course, be placed close to that side of the room in which the window is located, so that a line from the lens to the sitter would be parallel with the wall in which the window is.

Raise the tripod so that the bottom of the camera is on a line with the top of the sitter's head, then incline the camera-front toward the subject so that the face on the ground glass is below a line drawn horizontally across the middle of the glass; the line should cross under the chin, or lower. Upon looking at the presentation upon the ground glass, it will be readily seen whether there is a good light upon the sitter or not. Focus upon the eye, the eyelashes if possible. Use about the medium-sized diaphragm, or $\frac{f}{8}$ to $\frac{f}{12}$ according to light.

The most suitable background is something of a drab or light slate colour, placed as already referred to, so far back as to prevent the possibility of a shadow of the sitter being thrown upon it. A window-shade of the right colour makes a good background, or a piece of muslin coated with whitewash, to which a little lamp-black and glue have been added. Mix the lamp-black separately before adding to the whitewash.

The more rapid the plate, the better; expose from three to six times as long as out door, according to light; a long exposure followed by a slow development gives the best results.

Groups of 3 to 8 persons may be made successfully in an ordinary room. Select a large window with the sun upon it, raise the shade, and place an ordinary sheet over the whole window. Place the group in the diffused light. If the light is not strong enough, open one more window and throw a small sheet upon the floor where the sun will fall upon it; but ordinarily it is better to use only one window. Use a little smaller diaphragm than for a portrait, and expose a "Diamond" or "Special" plate 20 seconds. Don't hurry the development. No background is necessary, but if the side of the room behind the group is of a light appearance, it is better than dark colours.—(L. P. Ferris.)

Stereoscopic Views.—The appearance of high relief given by the stereoscope, is obtained by placing side by side two prints representing the same object, but photographed from slightly different positions, whilst the glass prisms of the stereoscope so direct the visual rays as to superpose the views, and but one picture is seen, although it is in reality a combination of both; thus the same object is seen from two different points of view at the same time, as is always the case when both eyes are looking at one thing, as they, with the object seen, of course form a kind of triangle. Views for the stereoscope are frequently taken simultaneously by two cameras, placed at certain angles and distances from each other, varying with the size and distance of the object to be photographed; but for portraits less trouble is involved by the use of a properly constructed twin camera. For views or groups situated some distance from the operator, two distinct cameras must be used (or one camera moved from place to place); the distance they must be placed apart, and the relative angle in which they should stand to each other, require careful consideration. For portraits or other objects, to which the cameras can be brought rather close, the angle should not be too great, otherwise the effect of relief will be distorted. In such cases an angle of about 2° must be used. For landscapes, as large an angle as 4° may generally be safely employed. To reckon the angles, suppose the nearest point of the view to be taken to represent the apex of a triangle, from each camera produce an imaginary straight line to the apex, these lines must represent the desired angle. As lines diverging from a centre may be indefinitely produced without altering their relative angle to each other, so the distance between the cameras will not affect the angles they should stand in, except that, for pictorial effect, distant objects may be a little distorted with good results, as will be the case when a large angle is used; whereas for subjects close to the camera, such distortion does not give a pleasing picture. Supposing an angle of 2° to be used, the distance required between the cameras will be about 1¼ in. for 1 yard, 2½ in. for 2 yards, 3¾ in. for 3 yards, 5 in. for 4 yards, 6 in. for 5 yards, 7½ in. for 6 yards, 9 in. for 7 yards, 10 in. for 8 yards, 11⅓ in. for 9 yards, 12½ in. for

10 yards, 19 in. for 15 yards, 25 in. for 20 yards. These remarks apply equally whether two cameras are used simultaneously, or whether only one camera is used, being moved from one position to the other as required.

Twin Lens Camera.—This is a camera having two double achromatic combinations of the same focal length, in other respects like an ordinary camera, except that it has two folding shutters at the back. Before focusing the object to be photographed, it is necessary to ascertain that the two lenses are in focus with each other. For this purpose, focus a statuette, or other convenient article, and when a perfectly sharp image is obtained with each of the lenses, upon the ground-glass slide, do not again alter the rack and pinion which adjust the lenses; any further adjustment necessary for portraits to be taken subsequently must be obtained by drawing in or out the expanding body of the camera, as when once the glasses are of the exact focal length, their relative positions to each other will not require any alteration, although the body of the camera will. As the two lenses are necessarily rather close to each other, the twin camera will only answer for photographs taken at a very short distance, otherwise the effect of relief will not be obtained. The glasses used are longer than they are wide, as two negatives are taken at the same time. All the operations are the same as before described for negatives; when the positive prints are obtained, their position must be reversed in mounting, the left-hand half of the print being pasted on the right-hand side of the card, and the right side of the print on the left side of the card.

Stereoscopic Views with One Ordinary Camera.—The camera must be placed on a board, having a movable slip of wood at each side which can be adjusted to the desired angle, against which the camera must be placed, first on one side to take one view, and then on the other side to take the other view. Mark cross lines on the ground-glass plate, to intersect a central point of the view from whichever side of the board the camera is standing; this is to ensure correct centres for the proofs. Two separate negatives are then taken; when mounting the prints, transpose their position from right to left. Dark slides are made for this process, to hold a glass sufficiently long to contain both views, and fitted with two shutters, by which each half of the glass can be exposed alternately. Having exposed the right-hand half, close its shutter, move the camera the required distance to the left, and expose the left-hand half of the glass.

Stereoscopic Views with Two Ordinary Cameras.—For instantaneous views of any landscape containing animate figures, it is necessary to use two quarter-plate cameras, with lenses of exactly equal focal length; they must be placed on a board provided with movable stops to regulate angle and distance. Great care is necessary in manipulation; the two shutters must be opened and closed at the same time, otherwise the two proofs will develop unequally. The plates should be collodionised and sensitised in the same baths, and to the same extent. For the developing bath, employ a vessel into which the two plates can be placed side by side, so that the same pyrogallic acid may affect both simultaneously. When mounting the positives, transpose the two views, left to right, as before described.

Stripping Films.—(*a*) One of the German photographic papers gives the following as a good method of stripping the film from the glass plate, but it is necessary to be cautious with the hydrofluoric acid—which should preferably be kept in a very weak solution. In commencing, the negative must be freed from the varnish, which is done best with methylated alcohol. The negative is then placed on a levelling stand, and coated over its whole surface with a rather thick film of 2 per cent. plain collodion; after setting, the plate is thoroughly rinsed with water, until all greasiness of the film disappears. The plate is then placed in a solution of 10 drops of hydrofluoric acid in 100 cc. of water; the solution should not be used stronger, as otherwise the film would probably frill. In order to avoid this failure entirely, it is well to add to two parts of the above weak hydrofluoric acid solution one part of alcohol. As soon as the film begins to loosen at the edges, the plate is removed from the bath and rinsed carefully, but thoroughly. After washing, the plate with the film side up is placed on a soft support (a few sheets of moistened blotting-paper), covered with a moistened smooth piece of good letter paper, and the latter slightly pressed by means of the ball of the thumb or by a rubber squeegee. The paper is next very carefully stripped off, together with the film; if this is done skilfully, the film will adhere well to the paper; the latter should have been cut a little larger than the film. In order to remove the paper from the film, and at the same time to give to the latter a suitable support, a well polished glass plate, a little larger than the stripped picture, is rubbed with talc powder, then coated evenly with collodion, rinsed with water, and placed aside for about 5 minutes to drain. The still moist plate is then coated with a 20 per cent. gelatine solution, and completely dried on a levelling stand. Such plates keep well, so that they may be placed in stock. After drying, one of these plates is placed in a dish, with cold clean water, and at the same time the paper, together with the film, is placed in the water; the whole is then brought in contact under water without producing air-bubbles; the plate is next removed, and is once more squeegeed, and the paper is stripped off while still moist. After drying, a sharp knife is passed through the edges, and the film, which has become strong and flexible, will easily leave the glass, and may then at once be used for printing.

(*b*) The first matter for attention is the preparation of the gelatine solution intended to form the stripping support, and this is simple enough if a little care be devoted to it. In order to shorten as far as possib'e the operation of drying, it is desirable that the solution should be as thick as can be conveniently employed, that is to say, that it shall contain as small a proportion of water to gelatine as possible. The quantity of bichromate is not of much consequence, provided it be not sufficient to crystallise out on the dried film; the sensitiveness of the film, i. e. the length of exposure that will be required to render it insoluble, will depend to a slight extent upon the quantity of chromic salt used; but as this is not a matter of great importance, it is better to err on the side of too little than too much.

Add a certain proportion of glycerine to the gelatine solution, for the purpose of giving flexibility to the stripped skin; for though the greater portion so added is no doubt removed in the subsequent washing operations, sufficient remains, or at least the effect, to produce a decided difference in the nature of the dried film. The following formula is found to answer very well:—

Nelson's No. 1, "flake" gelatine	1 oz.
Potassium bichromate	10 gr.
Glycerine	½ oz.
Water	5 to 8 oz.

Dissolve the bichromate and glycerine in the water, cold, and place the gelatine to soak for an hour or two, or until thoroughly swelled. The smaller quantity of water will be the better as regards rapidity of setting and drying, but the solution will be more difficult to filter, and will also require greater dexterity in applying to large surfaces, so that it will be advisable to commence with the larger quantity. Distilled or rain water should be used it convenient, if not, ordinary tap water, rendered very feebly alkaline with ammonia, boiled, allowed to cool, and filtered through fine filter paper may be substituted. The filtration should be performed at as high a temperature as possible in order to secure the greatest fluidity, and in the same manner adopted by the cook in making jelly, namely, by suspending a bag of wash-leather, felt, or other thick, close material, in front of a clear, hot fire. Through this the solution will pass with perfect freedom, in spite of its thickness as compared with an ordinary emulsion, and it will do no harm if the operation is repeated once or twice in order to secure a thoroughly bright result. The filtration may be performed in full daylight, as the solution and jelly are practically insensitive to light, only the dried film being rendered insoluble on exposure. The mixture need not, however, be unnecessarily exposed to strong light, as the decomposition that proceeds spontaneously is likely to be hastened in that manner, and the keeping of the jelly curtailed. If kept in a cool, dark place, it will remain perfectly soluble and good for many days, or perhaps weeks, though it is in its best condition for use when two or three days old.

To use this mixture it is only necessary to pour it warm upon the negative film to be stripped, the glass having been first accurately levelled. If any difficulty be experienced in preventing the solution overrunning the edges of the plate, especially when a very thick layer is applied, it may be desirable to apply some sort of edging to the negative. For this purpose, strips of paper may be pasted round the margin of the glass, so as to form a shallow dish, or a slight ridge may be raised by means of a mixture of paraffin wax and tallow, melted together so as to form a sufficiently plastic compound; but perhaps the simplest and easiest plan, where any such treatment is necessary, is to simply go round the edges with a piece of flannel, or a tuft of cotton wool, charged with any greasy material, in precisely the same manner as in "tipping" the edges with rubber substratum. This, by rendering the edges repellent, prevents the gelatine solution running over, and is sufficient with the thinnest gelatine solution, no matter how thickly applied.

So far as the mere application of the gelatine solution is concerned, the process is simple enough, and varies not at all, whether the negative be one of collodion or gelatine; but, actually, the treatment required by the negatives themselves depends upon the nature of the image-bearing film. In the case of collodion negatives, absolutely no previous preparation is required, as the collodion itself assists the dried gelatine film to "strip." Where, however, the plates are prepared by the operator himself, and are intended for stripping, adopt the practice of polishing the glass with talc previous to coating, even when it is not adopted for other reasons, as absolute immunity from accident is thus secured. The negative having been levelled, and covered with the bichromatised gelatine, is allowed to set thoroughly, and is then placed in an airy situation to become thoroughly dry. It is advisable not to resort to artificial heat, as it causes a tendency, when even a temperature far below that required to liquefy the film has been employed, to unevenness of the film after drying and insolation. It is desirable, also, that the plates be screened from strong light during drying, for the same reason, as otherwise the portions first dry become partly insoluble before the proper exposure is made, with the result that after stripping the film is apt to "cockle" on the slightest provocation.

After thorough desiccation, the negative is exposed to light for a sufficient time to thoroughly harden the whole thickness of gelatine. If sunlight be available, a few minutes will suffice, but as no harm arises from extending the exposure, it is as well to give enough. In diffused light, and during the winter season especially, two or three hours at least should be given, or even a whole day, the negative being placed in a printing frame and backed with white paper, which will reflect back the light that passes through the film. It should be turned once or twice during exposure, in order that both sides may be "attacked."

After exposure, the negative is placed to soak in clean water, preferably cold, or at least at the normal temperature of, say, not more than 60° F., though the gelatine is now quite insoluble even in boiling water. But there is a chance, with increase of temperature, of "reticulation," or a species of "frilling," from the gelatine partly leaving the glass during washing. This is more especially the case with gelatine negatives than with collodion. At first the washing water will be strongly tinged with bichromate, and must be changed at intervals until it remains colourless, when the whole of the soluble chromic salt may be considered to be eliminated. The transparent portions of the film will now be of a bright yellowish-brown colour, somewhat resembling a badly "pyro-stained" gelatine negative. To remove this objectionable tint, the plate is next soaked in a weak acid bath—either hydrochloric or sulphuric—of the strength of 1 oz. of the acid to 1 pint of water, in which it is allowed to remain until as free from colour as possible.

A better decoloriser is aqueous sulphurous acid, but it is an unpleasant solution to use indoors. Those who care to venture may secure the benefit of the sulphurous acid by adding the hydrochloric acid to a 10- or 20-gr. solution of sodium sulphite or bisulphite instead of to plain water; but this part of the proceeding should be performed out of doors, certainly not in the dark room.

The acid bath, if properly and sufficiently applied, will render the transparent portions of the film practically colourless, though a faint tinge may remain of yellow in the case of hydrochloric or sulphuric acid, or smoky green if sulphurous acid be employed. When this stage is reached, nothing remains but to wash the negative in three or four changes of water, and then to drain and dry it. When thoroughly dry, the point of a sharp knife is passed round the edges of the film, one corner is raised, and the whole film strips easily from the glass, forming, if the proper quantity of gelatine has been used, a stout, tough, and flexible film, perfectly flat, and in every way equal to glass for the purpose.

The only difference in the treatment required by gelatine negatives consists in the preliminary preparation by immersion in a 5-gr. solution of chrome alum acidified with sulphuric acid. This serves the double purpose of hardening and loosening the film from the glass, though it is not absolutely necessary — at least, so far as the loosening is concerned, as the subsequent acid bath suffices to effect this. But it is a *sine qua non* that the film be rendered thoroughly insoluble. After draining, a little of the bichromatised gelatine is poured into the sink; the negative is placed on the level, coated with the stripping solution, and, in fact, treated in precisely the same manner as already described. When it comes to the operation of stripping, the only difference will be that the film clings somewhat more tenaciously to the glass than is the case with collodion. It is also proportionately thicker than a stripped collodion film. If any difficulty should be experienced in stripping, a bath of very dilute hydrofluoric acid, as recommended by Pleuer, would no doubt settle matters.

With regard to the application of this method to paper negatives, probably with the specially prepared stripping films it is quite available.

It is, of course, a matter of necessity that the paper film should have been prepared for stripping, otherwise the adherence of the gelatine to the paper will be of such a tenacious character as to resist all treatment. But, given a properly prepared film, the action of the bichromatised gelatine, applied in the ordinary manner, would not have time or opportunity to penetrate the negative film, and reach the underlying layer of soluble gelatine. The only risk of failure lies in the chance of the soluble layer being hardened, and so cementing the image to the temporary support.

But if this method of working be not available, it is quite possible to form a stripping skin by coating a collodionised glass with the bichromatised gelatine; expose, wash, decolorise, and then, after freeing from all chromic salts, squeegee the "stripper" negative on to it, and after a short time immerse in hot water to remove the paper; then dry and strip in the ordinary manner. —(W. H. Bolton.)

(c) The stripping of a negative film when it is in collodion is a comparatively easy matter, but, in the present state of photography, it is quite necessary for one who takes up certain photomechanical processes to have a ready means of stripping gelatine films. The descriptions of such processes are meagre. Wilkinson, for example, in his excellent little book on photo-engraving and photo-lithography, describes methods of stripping collodion negatives only. Such descriptions are generally insufficient in detail. Any one taking them up and trying to work from them will find that he is not at once able to strip negatives and get satisfactory films from them, but that he has to work out all the details himself.

The process generally advocated is that of Plener, in which hydrofluoric acid is used to separate the film from the glass. Plener's method is so ingenious that one is sorry to pour any cold water on it, but apart from the use of hydrofluoric acid, which every one will avoid who possibly can, it would appear that the etching action of the acid on the glass has nothing to do with the stripping, inasmuch as almost any other acid will act as well as hydrofluoric acid.

This observation was made by W. B. Bolton. The action, whatever it is, is really the same as the "frilling" of the plate. Although almost any acid that is strong enough or that has a strong enough action on gelatine will serve to strip, it is, perhaps, scarcely correct to say that any other acid will do as well as hydrofluoric acid, inasmuch as there are differences in the certainty in the action of different acids. Sulphuric acid is the most certain in its action of all acids, hydrofluoric included

The difficulties that will generally be found in stripping are as follows:—(1) The films refuse to strip at all. A process which will be quite successful with a negative freshly developed and fixed will often be found not to work at all with a negative that has been treated with alum, and is, say, a year old. (2) The stripping takes place between the new support and the film, instead of between the film and the glass. (3) The film after stripping stretches so that not only is the negative to a larger scale than before—and with a corresponding increase of density—but probably there is likewise distortion, as it is highly improbable that a film will stretch exactly to the same extent in all directions. (4) The film is so hard and brittle when dry that it cannot be handled without danger of cracking it. (5) The film twists or curls in drying, so that it is impossible to get perfect contact between it and a flat surface, such as a collotype film.

If the following directions be precisely carried out, it will be found that any negative, however old, may be stripped with certainty and without encountering any of the difficulties just enumerated. It need scarcely be mentioned that, if the negative has been varnished, the varnish must first be removed by the application of hot methylated spirits.

The following is made up:—2 oz. hard gelatine and 10 oz. water. The gelatine is, of course, soaked in the water till it is soft, when heat is applied. The solution should be heated to not very far short of the boiling point, and should then be filtered through flannel.

A negative to be stripped is warmed, and accurately levelled, and a certain amount of the gelatine solution is poured on the surface and guided with a glass rod till it covers the surface evenly. It is of great importance to measure the quantity, as the ultimate thickness of the film depends on this, and it has to be borne in mind that printing has, if the film is to be used as a reversed negative, to go on through the gelatine.

A quantity of 4 oz. per square foot will be found suitable for average work. This gives a film, when dry, of about $\frac{1}{100}$ in. thick. This sounds very thin, but, in fact, it is a good stout film. The film of an average gelatine dry plate, when dry, is only about $\frac{1}{2000}$ in. thick. Still $\frac{1}{100}$ in. will not interfere with ordinary work. For very delicate work, the amount of the gelatine solution may be reduced to 2 oz. per square foot. It is not advisable to use less than this, as otherwise the films will be too delicate for free handling. It is quite possible to flow as much as 10 oz. per square foot on glass without any special arrangement for preventing it from overflowing the edges, but a film of the thickness so got is far too thick for any practical use.

If, however, such a film be wanted for anything, it will be necessary to give four times as long in each solution as is hereinafter directed, as it takes a long time for any liquid to penetrate a very thick film.

A saturated solution of chrome alum is taken, and there is added to it, drop by drop, liquid ammonia, till there is the slightest possible permanent flocculent precipitate. This is merely to neutralise any free acid that there may be, as any such free acid greatly impairs the setting powers of the alum solution.

The gelatine solution having set on the plates, the latter are placed for 5 minutes in the chrome alum solution. They are then removed and are washed till all the blue colour of the chrome alum has disappeared. They are then placed in a bath of methylated spirit for $\frac{1}{2}$ hour. They are taken from this, the surface is blotted with blotting paper, and they go into a bath of 1 oz. sulphuric acid, and 2 pints water. Use ordinary commercial sulphuric acid; the exact specific gravity is not of much importance, as a considerable variation in the strength of the bath is permissible.

The following solution is now needed:—1 oz. liquid ammonia, 1 oz. glycerine, 2 pints water. The films are left in the sulphuric acid bath till the greasiness caused by the alcohol disappears; this will take about $\frac{1}{2}$ hour. At the end of that time, it will be found that the corner of a film may be lifted, and that the whole will leave the glass with the greatest ease. The films go direct from the sulphuric acid bath to that of ammonia and glycerine. The object of the glycerine is to secure flexibility of the films, the object of the ammonia is to neutralise the sulphuric acid. It takes a long time to wash sulphuric acid out of a thick film, and if a long time be given in this case, the film will stretch. The small amount of sulphate of ammonia produced in the film by the acid and the ammonia is quite harmless.

Glass is prepared by rubbing the surface with a solution of a few grains of beeswax in each ounce of benzine, and by polishing this away with powdered talc. A film is taken from the last solution as soon as it tastes of acid, probably in about 5 minutes; it is placed on a piece of glass, a pad of blotting paper is placed on the back of it, and the squeegee is applied with great vigour. The plate supporting the film is then placed in a fairly warm place, so that the latter may dry; but it is necessary, after a few hours have elapsed, to paste down the edges with narrow strips of paper and gum solution, otherwise they are sure to rise from the glass before the whole film is dry, and it will be found impossible to get flatness. An attempt must not be made to strip the film from the temporary glass support until it is perfectly dry. Then it is only necessary to insert the thin blade of a knife, when the film will come away in a form in which it is beautifully flexible, and may be printed from either as a direct or a reversed negative.

It is to be observed that if the film, before it goes into the sulphuric acid, be dried spontaneously instead of by the aid of alcohol, the gelatine support will probably part from the film instead of the film parting from the glass.

The acid bath may, of course, be used for a long time; in fact, as long as it acts. The ammonia and glycerine bath may be used as long as it continues to smell distinctly of ammonia.

On trying to dry the stripped films on vulcanite, it was found impossible to prevent them from leaving the surface before they were dry, with the effect that they were hopelessly far from flat.

The process as described reads as if it were very complicated. It is not really so. A negative may easily be stripped and be drying within 2 hours of the time of beginning operations, and quite a number may be done at the same time. The drying is the thing that takes longest. With films of average thickness it takes 24 hours.—(W. K. Burton.) (See also iv. 366, 395.)

Hydroquinone.—The use of hydroquinone is becoming more extensive. Hydroquinone with sulphite and soda has recently been strongly recommended for gelatine plates, and Vogel says that he now uses hydroquinone to the exclusion of all other developers for paper prints, as well as for gelatino-bromide plates. No other developer, in this writer's opinion, permits of such easy, clean, and completely certain work. This is a very strong expression of opinion from an able worker. If in the hands of others it ensures a like favourable verdict, there will have to be an improvement in the method of using pyro, or that agent must in all probability encounter neglect similar to that which, for all save printing and reproduction processes, has come upon iron development.

Although now using hydroquinone only for the development of paper prints, Vogel encountered some difficulties and objections, which, having overcome, he describes for the guidance of those who may follow. To begin with, he mentions that with over-exposure, even in slight degree, the picture, especially if the film contain much silver iodide, readily acquires a disagreeable greenish hue. He has recently found that the tone of the picture depends essentially upon the amount of soda carbonate present in the developer. With a solution prepared according to the following formula:—

40 gr. crystallised soda sulphite,
5 gr. hydroquinone,
$2\frac{1}{4}$ oz. water,
50–150 gr. crystallised soda carbonate,

it was found that when the soda carbonate was in small proportion—i. e. up to 75 gr.—the tone of the print was always greenish; with a larger proportion of soda the tone improved, becoming eventually black or blackish brown.

With 75 gr. of soda carbonate good results were obtained, provided the exposure was exact, but not if there was over exposure. A very great increase of soda produced some blistering. Potash carbonate possesses the advantage, for the development of paper prints over soda, that a greenish tone is never obtained with it, and is therefore to be strongly recommended for positive work.

The following mixture was prepared:

40 gr. crystallised soda sulphite.
5 gr. hydroquinone.
$2\frac{1}{2}$ dr. water.

When perfectly dissolved (hastened by standing the bottle containing the ingredients in warm water), 50–54 gr. of potash carbonate was added. A larger proportion of potash carbonate than this causes, especially in warm weather, considerable frilling. For use, 1 part of this solution is diluted with 5 parts of water. The developer in the concentrated form as above, keeps good for a long time; when diluted to the strength given for use, it remains good only for about 2–3 weeks. The strong solution is, on account of its keeping properties, very convenient for use on a journey. When using with gelatine plates, Vogel states that he obtained very good results with this formula, and that it may be especially recommended for instantaneous negatives on account of the very full amount of detail brought out by it. The development also proceeds quickly.

It is important to notice that the soda sulphite is in good condition—has not effloresced by keeping. On account of the greater keeping properties of a concentrated solution he now gives the formula in the following shape:—

160 gr. crystallised soda sulphite.
20 gr. hydroquinone.
1¾ oz. water.
300 gr. crystallised soda carbonate.

The precaution previously mentioned of ensuring that all the hydroquinone is dissolved before the addition of the alkali must of course be observed. For use, 2 parts are diluted with 5 parts of water.

Both the potash and the soda developer can be varied so as to suit differing characteristics. For plates working with too much vigour, less water may be used in the developer; while, on the other hand, plates yielding an image deficient in vigour may be treated with a solution to which more water has been added.

An item having an important bearing on the general extension of the use of hydroquinone is the much lower price at which it is now procurable. In Germany it is now less in price than pyrogallic acid, the cost being about 10*d.* per oz.

Flash Light.—In times past, some fault has been found with flash-light pictures on account of the anxious expression of the subject, caused by the expected explosion of the powder, or the closed eyes, which are characteristic of pictures secured by flash lights that are not practically instantaneous.

It follows that a flash light must do its work "quicker than a wink," and that it must be ignited by some device other than a fuse or strip of paper, either of which gives warning, and thus puts the subject on guard. Flash-light lamps are undoubtedly good, but they are all limited in certain ways. In the first place, it is necessary to compress a bulb to force air through a greater or less length of tube. This requires some effort on the part of the operator, and practically prohibits him from including himself among his subjects. If he does attempt to do this, the rubber tube leading from the bulb to the lamp must necessarily form an unsightly addition to the picture; and, furthermore, the tube is limited as to its length, on account of the air friction, which so reduces the blast in a tube of considerable length as to entirely defeat the operation of the light.

After enumerating these objections to the ordinary flash-light lamp, it is perhaps unnecessary to allude to the matter of expense.

In Figs. 72 and 73, is shown flash light apparatus, the cost of which is practically nothing, as the needed materials may be purchased for a few pence, and the labour involved is a matter of only a few minutes. A de-

Fig. 72.

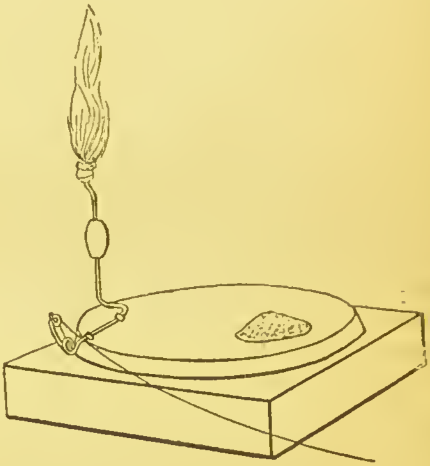
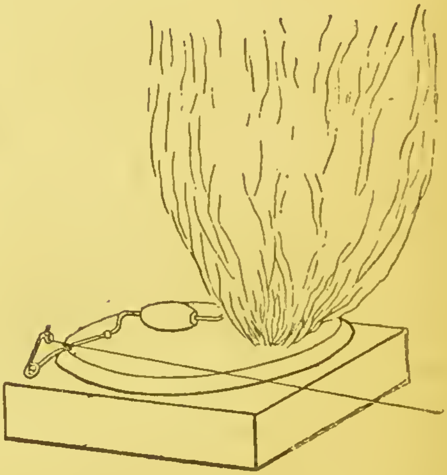


Fig. 73.



scription is hardly necessary, the engravings tell the whole story.

Two loops soldered to the bottom of a small tin pan receive a wire, which is bent at one end, forming a spiral, into which is inserted a little roll of asbestos. A fish-line sinker is placed on the wire previous to bending, and near the pan the wire is bent to form a shoulder, which holds the wire in a stable position when raised, as shown in Fig. 72. The other extremity of the wire is bent at nearly a right angle and formed into a loop, then returned to form a practically T shaped arm with an open eye at its extremity. A stout black thread of sufficient length to reach as far as may be required is tied in the loop.

At the point in the surface of the pan where the asbestos strikes when pulled over, a shallow cavity is formed by burnishing the tin with a rounded instrument like a tool handle, the tin being placed over a cup, a box cover, or something of that kind, which will support the metal around the cavity during the operation of burnishing.

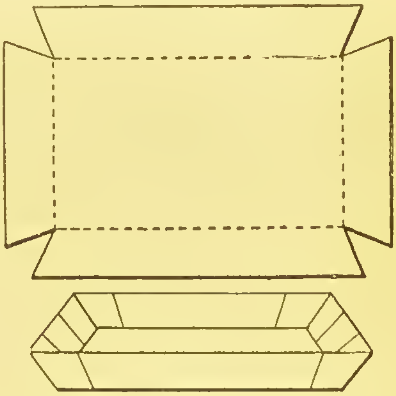
The pan is secured to a heavy wooden block, or to any fixed support, by means of two or three tacks driven through its rim. One or two boxes of Blitzpulver should be placed in the cavity in the tin; a few drops of alcohol are poured on the asbestos; the apparatus is placed on a step-ladder or other high support, which is located at the side of the camera in such a position as to prevent the light of the flash from entering the camera tube. A large piece of white paper is suspended at the back of the apparatus, and 18–24 in. distant. If the operator is not included among the subjects, the black thread is simply connected with the lower loop, so that a rearward pull of the thread will tilt the wire arm forward. If the operator desires to include himself in the picture, the thread is slipped into the eye at the end of the wire, so that pulling the thread from the front will tilt the wire arm forward. Now, everything being ready, the alcohol is lit, the operator takes his position, pulls the thread, and the thing is done.

When the subjects are so posed with reference to the source of light as to produce undesirable dark shadows, this trouble may be avoided by arranging newspapers so as to reflect more or less light on the shaded side.

To secure good flash-light pictures, two things in addition to a good instrument are required: one is an instantaneous light of sufficient intensity, the other is an instantaneous plate of the kind known as isochromatic or orthochromatic.

Trays.—Among the items of expense in the list of the amateur photographer's supplies will be found trays for developing, fixing, intensifying, toning, &c., and the temptation is often great to make one or two trays answer all purposes; but modern photography forbids the double use of trays, so that the operator must either purchase or make trays for himself. In Fig. 74 is seen, in the upper figure, a pasteboard blank, which, when creased as indicated in the dotted lines, bent up and fastened at the corners by pieces of cloth glued inside and outside as shown, forms a foundation for a serviceable tray. All that is required to complete the job is to fill the pores of the pasteboard and cloth with paraffin.

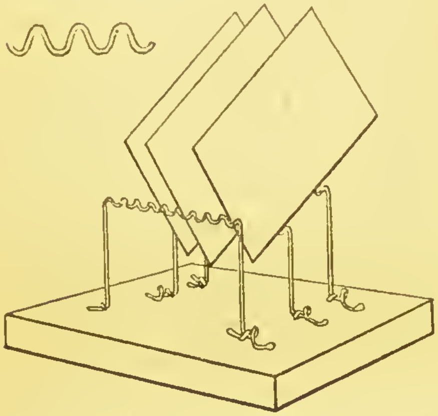
Fig. 74.



There are two ways of doing this. One is to dip the tray into paraffin melted in a pan of suitable size; the other way is to melt the paraffin by means of a hot iron, and allow it to drop on the pasteboard, afterwards spreading it with the hot iron. In either case a liberal supply of paraffin should be left in the corners. Paraffin candles will furnish the material for saturating the tray when paraffin in bulk is not available.

Rack.—In Fig. 75 is represented a simple, easily made, and efficient nega-

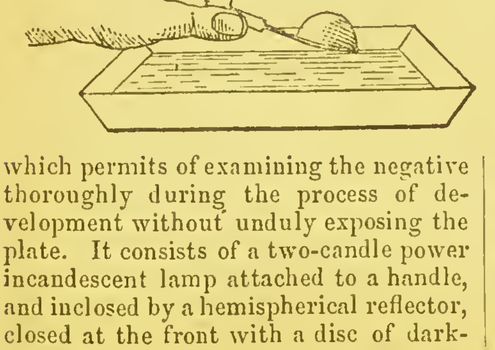
Fig. 75.



tive rack. It consists of thin wire frames pivoted to the base-board, and provided with corrugations for receiving the edges of the plates.

Plate Inspector.—In Fig. 76 is shown a method of dark-room illumination,

Fig 76.



which permits of examining the negative thoroughly during the process of development without unduly exposing the plate. It consists of a two-candle power incandescent lamp attached to a handle, and inclosed by a hemispherical reflector, closed at the front with a disc of dark-ruby glass. The lamp is held near the plate. All the light is thrown downward, so that the eyes receive only the light reflected from the plate. Furthermore, only a small section of the plate is exposed to the light at any time. When the lamp is not in use in the manner described, it is either laid face down on the table, or suspended so as to light the dark room.

Fading Prints.—The fading of silver prints on albumenised paper is an interesting matter, but one about which we know very little. Those who have given the subject any attention have been struck with the singular fact that skill and care on the part of the maker of the prints is no guarantee of their permanency. In fact, numerous cases could be quoted where prints made in the most slovenly manner, with poor materials, and by men so ignorant that they hardly knew the names of the chemicals handled, have actually outlasted the best efforts of skilled and careful photographers.

In most other departments of practical photography we could say that more careful investigation would help us in determining the causes of fading, even if it proved impossible to entirely do away with them; but the subject is an exceedingly difficult one, partly owing to the complex chemical nature of the silver print, and partly from the impossibility of watching the behaviour of batches of prints, or even of individual prints out of a given batch, for years at a time, and of obtaining data as to their manufacture which would be of any practical value.

From the earliest days of silver printing imperfect removal of the hyposulphite after fixing has been cited as a pregnant cause of fading. The dangers from the said source have been much overrated. Assuming that a good commercial sample of the hyposulphite is used, and that no foreign matter like acids be allowed access to the fixing bath, there is really no reason why a print should not last well, even if quite a large quantity of the fixing salt remains in the paper.

Prints made by an experienced maker

of albumenised paper, which had merely received a couple of rinses after fixing, and were then immediately dried, when several years old had remained perfect in every respect.

Every one who has tried silver printing is aware that even the successful toning of the print cannot be accomplished if there is free silver nitrate left in it, but that the said salt must be washed away before the print is risked in the gold bath. Neglect of this means red patches and streaks, alternating with ashy blue tints and mealiness over the entire print, and oftentimes precipitation of the gold in the bath, and consequent stoppage of the toning action. But this is not all.

The proper forming of the image on a silver print demands the harmonious chemical action of three distinct compounds of silver: first, silver chloride; second, the organic chlorific compound of albumen and silver nitrate; and third, free silver nitrate in excess. When a print is taken from the frame and washed, the chloride and a certain portion of the darkened organic compound remain unaffected, while the free nitrate, and in all probability a considerable amount of the organic compound are washed away. Now, the point is whether the too complete removal of this organic compound, in the washing before toning, may not injure the stability of the print by robbing it unduly of one of its important component parts before the gold has had an opportunity of depositing upon it, and ensuring its permanent abode in the print. The objection may be raised that the hyposulphite would remove it in the fixing, but if the gold is well deposited upon it it would remain.

This idea may seem far-fetched, but we can find analogies to it in several departments of photographic chemistry. Take, for instance, the manufacture of washed collodio-bromide pellicle. Here the silver bromide is formed in the collodion by adding silver nitrate to collodion containing a soluble bromide. In order to get rid of the lye salts which come from the double decomposition between the bromide and the nitrate, the emulsion, after setting, is washed in water to remove them. But it sometimes happens that the pyroxyline is of a variety that will not bear the washing without parting with an organic compound between the silver and the pyroxyline, which seems to form during the ripening of the emulsion. When such is the case, the resulting pellicle gives thin, foggy negatives, and is in every way unsatisfactory.

It was long ago discovered that silver nitrate reacts with such substances as albumen and gelatine (less so with pyroxyline), entering into combination with them; and the albumen compound is the important colorific substance of the silver print. Another fact is, that prints from which all traces of silver are thoroughly eliminated, as, for instance, by prolonged boiling in some chlorinous solution, refuse to tone.

We are therefore driven to the conclusion that prints must contain an appreciable quantity of silver in order to take the gold properly during the toning; but, on the other hand, we know that an excess of the silver is incompatible with good toning. It may, then, be fairly asked how long the prints ought to be washed, before the toning, and the answer to this question can be found only in practical experience. A batch of, say, 150 8 in. × 5 in. prints put into one of the largest porcelain pans obtainable at the stock dealers, and set under an ordinary dark-room tap, would contain a large amount of free silver after $\frac{1}{2}$ hour's washing, while a dozen prints of the same size would probably be ready to tone after 10 minutes' immersion or less.

But another objection may be raised. The question will be asked why some prints from every batch fade in a comparatively short time, while the rest remain white for years and years. Now remember that, excellent as our commercial brands of albumenised paper are, it is, nevertheless, an impossibility to coat sheets with albumen so evenly that it shall be of just the same thickness or body at every part of the sheet. The behaviour of the prints, both during the printing and after they are finally dried, proves this. Every practical printer knows the value of the thick ends of the sheet, and, if he is a careful workman, reserves them for the most difficult subjects. Prints made on these "thick ends" will curl in a refractory manner when dried, owing to the heavy body of albumen on the paper, while those made on the more central portions of the sheet remain flat.

Remembering this, is it not fair to assume that prints, even when made from the same sheet of paper, will not part with the organic silver compound equally when washed before toning, owing to the variable thickness of the albumen, and will thus present to the gold a variable quantity of the important organic constituent?

The fact that prints toned in the lime chloride toning bath, without any washing whatever to remove the silver after coming from the frame, last fully as well as others made in the usual way (better, indeed, in some cases), is another item in support of the view advanced.

An enumeration of all the possible causes of the fading of silver prints would be indeed lengthy; but attention may be drawn to the want of reliability of a mountant, which, until very recently, was always considered quite safe. This is gelatine, either when dissolved in water alone or in water with alcohol added to prevent cockling of the mount—not only as a mountant in the usual sense, but also as a material for cementing prints to glass, or as a sizing. On the other hand, prints over 20 years old, which had been mounted with starch, have lasted well, while almost every gelatine-mounted print has faded more or less, according to its age.

The important matters to care for in printing, as regards permanency, are:—A good albumenised paper, free from smell, worked in as strong a silver bath as the salting of the paper will allow, toned rather rapidly after the minimum of washing, and, if necessary, adding common salt liberally to the toning bath to make up for it; to wash off the gold thoroughly before fixing, and to have the fixing bath strong and lukewarm to the finger; to work the prints about thoroughly during the fixing and the first rinses after fixing; to wash them in rapid changes of water; to avoid gelatine as a mountant, and, finally, to rub in wax after rolling, the best means being to reduce pure white wax to the consistency of soft butter with turpentine and a little oil of lavender. This is better than the ordinary burnisher.—(E. Wallace.)

Reducing Intensity of Negatives.—The *clichés* may be too intense, either from yellow fog, over-development, or local opacities. We have nothing to say on the means employed to remove yellow fog—they do not alter the character of the picture, nor on those which attenuate the contrasts or local opacities, which, if done by redevelopment, answer pretty well; but we think that the reduction of *clichés*, generally too intense, is effected by chemical actions which are often objectionable. Among the processes employed for the purpose in question, the old one first employed, both in the collotype and the collodion process, consists in treating the *cliché* with a solution of potassium cyanide. It is the best, on account of its simplicity, and of not requiring much after-washing. The drawback in the gelatine process is that the solution of the commercial article has, on account of its strong alkalinity, a tendency to produce blisters and frilling by softening the film. This can, however, be easily prevented by using pure potassium cyanide in solution in alcoholised water. The next process in order of publication is that devised by Alexis Gaudin. The reduction is effected by ferric sulphate (Monsel's salt). This process requires to eliminate the iron salt by first washing the gelatine film in a diluted solution of hydrochloric, citric, or oxalic acid, &c. It is little employed. Then comes Spiller's process, which consists in treating the *cliché* by a solution of cupric bromide and common salt; that of Farmer, who uses potassium ferricyanide in solution with sodium thiosulphate; and, lastly, Monckhoven's process, by which the reduction is effected in attacking the silver with ferric oxalate, the silver salt formed being dissolved by sodium thiosulphate, as in Farmer's process. The later processes—those of Farmer and Monckhoven—require prolonged after-washings to eliminate the thiosulphate. For this reason the process of John Spiller is preferable, as the solvent of the cuprous and silver bromides is simply the common salt, an entirely harmless compound, should any traces of it be left in the film.

As it is seen, in all these processes the intensity is reduced by dissolving the metallic silver forming the image. If employed for the reduction of *clichés* generally too intense from over-development, the relative value of the local intensities may be little altered, provided the operation be conducted with great care, otherwise—and, indeed, this is of frequent occurrence—it happens that the penumbras and the details in the shadows, being formed by their layers of metallic silver, are dissolved, and, as a consequence, that the *cliché*, if not spoiled past remedy, has lost that admirable gradation from lights to shades, that delicacy of details, which makes a photograph such a beautiful realistic image of nature. A rational process would be to reduce the intensity not by dissolving the silver, but by transforming the colour of the image into one more actinic, or rendering the *cliché* more transparent, so that not only the desired de-intensification would result, but if the intensity were too much reduced it would always be possible to strengthen it.

For example, the *cliché* previously soaked in water is immersed in a very diluted solution of nitro-bromhydric acid or of nitro-chlorhydric acid (aqua regia). In the solution, the image, viewed by transparency, seems to intensify on account of the formation of the silver bromide (or chloride), but when exposed to sunshine for a certain period, it becomes more transparent from the reduction of the silver haloid, and turns to a bluish or violet-black, that is a more actinic colour than the original one. The operation should be made by diffused light, and the *cliché* allowed to dry before exposure to the luminous action, for, if dried in the light, the silver reduction would be of unequal intensity, the parts drying first being the lightest. In fact, when exposed under water, or, better, in presence of an absorbent of chlorine or bromine, the reduction is more complete and darker, which is generally advantageous. Of course, the de-intensification is proportionate to the more or less complete transformation of the metallic silver, the image, into silver haloid. And it is in this where resides the difficulty of the process; it requires some experience to succeed. There is, however, little danger of spoiling the *cliché*, for should it be too much weakened from being bleached through, the remedy is at hand; it suffices, after the insolation, to redevelop with a very weak developer—pyrogallol, eikonogen, &c., or to intensify with mercuric chloride, or by any other intensifying processes. No fixing is required after these operations. It is only necessary to well wash the *cliché*.

We have also experimented with iodohydric acid, and, in lieu, with iodine; but the results were not generally as good. The silver iodide does not blacken in the light, and remains apparently not acted on, and when treated by the developer gives rise to a great increase of intensity. This can be regulated during the redevelopment, and an after-treatment with a solvent of silver iodide, sodium thiosulphate, &c. The iodide process has given satisfactory results for the intensification of very weak negatives. As said above, the redevelopment should be done after insolation, and with diluted developers, in order to have the action well under control.—(P. C. Duchochois.)

Ghost or Shadow Pictures.—The majority of amateur photographers are not aware of the entertaining and amusing results that may be obtained apart from the ordinary routine.

One very striking picture that may be made is a man seated at a table writing, and his own ghost—through which the objects of the room may be faintly seen —standing behind his chair. Or a man starting back in terror from his own ghost, or even a pair of them.

Another very amusing picture is two or three perfect busts or figures side by side, but both or all three the same person. It would take too much space to give a thorough description of this style of photography; but from directions for making the above-mentioned pictures the operator can obtain any variety he chooses by following the principles.

Make a background the required size by stretching out some black material. Place your subject—draped in white or light-coloured clothing—in position to the right or left of the centre of the background. Focus and expose for half a second, and the impression on the plate will be a shadowy, ghost-like figure. Next take a chair and a table, and place the chair in the centre of the background and the table on the opposite side of the ghost. Seat the same subject in the chair at the table, focus again, and give full exposure, which, if the light is good, should be about 2 seconds. Develop and print in the usual way.

Any object that you wish to be seen through the shadowy figure must be subjected to ¼ minute's exposure before the figure is placed in position.

To make a twin picture, place the subject in position on the right of the centre of the black background, focus, and expose for two seconds in good light. Now place the subject on the left of the centre of background and focus again, giving the same exposure. If you have left room enough between the two figures, you may now take a chair and place it in centre of background and seat the subject in it, focus, and give again the same exposure. Develop plate, and you will have the two, or three, twin brothers. This line of photography offers a great scope for originality and skill.—(A. S. Green.)

Acid Sulphite.—For some time past German photographers have been speaking very highly of the merits of solution of acid sodium sulphite as an addition to the fixing bath.

When pyrogallol was first used for dry-plate development in conjunction with alkalies, several formulæ were proposed using sodium sulphite as a preservative agent, and it was found that the addition of sulphurous acid had a very beneficial effect. This acid was added directly, as such, in solution, or it was developed in the mixture of pyrogallol and sodium sulphite by the subsequent addition of sulphuric acid, which caused the formation of a certain amount of sulphurous acid in the fluid, and at the expense of the sodium sulphite. No matter which method was employed, the final result was the formation of a small quantity of acid sodium sulphite, which preserved the pyrogallol for a much longer period than when ordinary sodium sulphite was used. But the trouble about these early efforts at preserving pyrogallol was that the quantity of acid sulphite present was small compared with the amount of ordinary sulphite. There is now made in a very convenient form a very strong solution of acid sodium sulphite, that in the compounding of developers will prove extremely useful. The material is in the form of a pale, yellowish fluid, smelling strongly of sulphurous oxide gas, with which it is saturated, and containing over 50 per cent. of acid sodium sulphite in solution. That is to say, it contains half its weight of acid sodium sulphite, while ordinary sodium sulphite in crystals contains half its weight of normal or neutral sodium sulphite. From the nature of the two salts, the acid-sulphite solution contains, therefore, twice the amount of the preserving element, sulphurous oxide, which the ordinary sulphite crystals contain. This would be true if the ordinary sulphite crystals were pure, but it is next to impossible to make them so, for they usually contain 4–6 per cent. of sodium sulphate, and 2–3 per cent. of sodium carbonate. The new acid-sulphite solution contains a little sodium sulphate, but the excess of sulphurous oxide gas with which the fluid is charged compensates for this.

Such is the new material placed in

the hands of the photographer. Now a few words as to its uses.

The first important application of the new fluid is in the fixing bath. If to a quart of fixing bath (one to four) we add about 2 oz. of acid-sulphite solution, the bath is rendered acid, but no change takes place otherwise. In this bath any negatives can be fixed, and with a rapidity and clearness that is really startling. Some of the slow varieties of plates are remarkably long in the ordinary bath before they are fixed nicely; but in the new acid-sulphite and hypo bath they fix in about one-fourth the time ordinarily taken. And what is yet more pleasant to note, they are remarkably clean and free from stain. In fact, they look exactly like plates developed with ferrous oxalate after they come out of the new bath, although they may be badly stained before fixing. The new fixing bath is beyond question the best remedy for stained plates from organic developers. One thing must certainly be remembered at all times, the fixing bath must be kept acid by the addition of new acid-sulphite solution from time to time in order to have it maintain its efficiency as a clearing bath. If the proper care is exercised, the use of the alum clearing bath can be entirely omitted when the new acid-sulphite solution is used; thus eliminating a step in the present negative process when clear, crisp, and quick negatives are desired.

We must now say something about the application of the acid sulphite to the developer. With pyrogallol the application is very simple: to every grain of pyro in solution add one drop of the acid-sulphite solution as a preservative. Thus you may take:—Pyrogallol, 1 oz.; acid sulphite, 1 oz.; water to make 10 oz.

This solution contains $5\frac{1}{2}$ gr. of pyro to the fluid drachm, and will keep a long time. To develop: in 1 oz. of water use $\frac{1}{2}$–1 fl. dr. of the above solution, with $1\frac{1}{2}$–2 fl. dr. of alkaline solution, made as follows:—Sodium carbonate (crystals), 5 oz.; water to make 10 oz.

In the case of eikonogen it works equally as well as with pyro. In this case the formula becomes:—Eikonogen (finely powdered), 1 dr.; acid sulphite, 1 dr. (fluid); water to make 10 oz.

Dissolve the eikonogen first, then add the acid sulphite. This solution contains $\frac{3}{4}$ gr. of eikonogen to the fluid drachm, and keeps as well as the pyro mixture above. In developing, if sodium carbonate is used, to every ounce of the eikonogen solution add 1–2 dr. of the solution given above for pyro, and no water. If potassium carbonate is preferred, use 1–2 dr. of the following solution:—Potassium carbonate (dry), 3 oz.; water to make 10 oz.

In each case the negatives come up clear and full of detail, without any tendency to fogging. Judged by experience with the ordinary developers, these new mixtures with acid sulphite work a little more quickly; and if the negatives are fixed in the acid-sulphite fixing bath, the result leaves nothing to be desired as to quality.

With hydroquinone we have not yet obtained any desirable results, the mixtures tried working much too slowly to be of practical use.

As the developers given above work more rapidly than those ordinarily employed, care must be taken in regard to the light used in the dark room that it is of proper non-actinic quality. It is best to use as little light as possible under any circumstances, but always enough to see what you are doing.

We are sure that those who use the new acid sodium sulphite will find it a great help to the production of clean, stainless negatives, closely resembling those of wet-plate days.—(*Anthony's Bulletin.*)

Pinhole Photographs. — Very good photographs indeed can be taken without the use of a lens by means of a pinhole, and Earp says that, with respect to the opening, it will be found that a fine needle heated to redness, and just pressed through a piece of thin, hard cardboard, will pierce a hole of suitable size, any little burr being removed by burning it off with the side of the hot needle, the point of which, being again gently inserted in the opening, will make it clear and round. If it be convenient, the better plan is, of course, to get a watch-maker to drill a hole in a thin piece of sheet metal, which, being blackened, as must be the cardboard, is ready for use. It may be attached to one of the lens stops by strips of thin gummed paper, or, if preferred, a piece of metal, cut to the pattern of the stop, may be pierced centrally and used in its place.

The lenses being removed from the mount, the latter is placed on the camera, the focusing glass is pushed forward to within 6 in. of the pinhole, and the image observed for sharpness. By turning the camera towards the sun, and getting his image as sharply defined as possible, especially if it can be observed through the branches of a tree, the approximately best position for the focusing glass is obtained. In finding absolutely the best position, the side-swing is useful, as, by setting a plate at an angle and exposing, the resulting negative will be a guide in enabling the experimenter to get the best possible results.

It must be borne in mind that as a rule the pinhole should be as small as possible, for if the opening be too large a pleasantly sharp image cannot result.

The time of exposure for an Ilford ordinary plate may be 4 minutes for a tolerably open view on a fine day, and up to 10 minutes, or even more, for the view of a shady lane. It is not easy to over-expose sufficiently to spoil the negative, as the very weak light does not readily pass through the film. Developing should be started with a minimum of alkali, and should be carried on tentatively, as the shadows suffer if any more than the absolutely necessary proportion of alkali has been present.

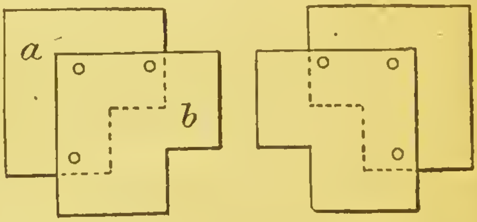
If a finder is attached to a camera, it will be useful for centring the view, as unless exceedingly well illuminated, it is difficult to dispense with some such contrivance. The only difficulty in the operation is in the focusing with the small amount of light available, and the chief things to avoid are placing the focusing glass too far from the opening and under-exposing.

Softening Pictures.—The likenesses produced by photograph have, in many cases, a harshness which is extremely disagreeable. The camera will tell the truth, but its effects may be toned down so as to give the features something of that softness which is generally imparted by the portrait painter. For this purpose use a lace curtain stretched between the sitter and the camera—the nearer it is to the latter, the more softness it imparts. The grain of a chalk drawing is produced by the threads, and characteristics of the model which would not bear prominence are pleasingly softened down.

Copying Pictures.—Pictures and engravings can be easily reproduced by photography. If framed, the glass must be removed, or the reflected light will interfere with the image formed by the lens. The picture must be placed in a good light, and the front of the camera must be parallel with it, or the copy will be distorted. A small stop should be used, and the negative rather under-exposed than otherwise. Copies of photographs, except on a reduced scale, are seldom as satisfactory as the original, for the grain of the paper gives a peculiar mottled effect to the picture.

Mounting.—(*a*) An appliance calculated to be useful, especially to amateurs, when mounting photographs upon cards to show a definite margin, has been brought forward by Starnes. Two pieces of card *a b* (Fig. 77) are fixed by three tacks upon a drawing board, in the position shown. The corner of the mount is pushed under the card *b* until it butts against the edges—shown by dotted lines—of the card *a*. The print is then laid down with its

Fig. 77.



corner fitting the angle cut in *b*, and thus any number can be mounted upon the cards without the necessity for measuring and marking each mount. It has been suggested that if two corner-fittings (as shown) were used instead of one, the direction of the print upon the mount would be truer; and that if the photographs themselves were not cut exactly of one length, it would be seen, and could be allowed for, keeping the same amount of margin at each end. The top or bottom of the mount should be placed in this double fitting, rather than one of the sides, as a little difference in the height of a print upon the card is permissible, but it must be central as regards the sides.

(*b*) Most photographers are now fully aware that a photograph when wet is larger than when it is dry. This is owing to a property which paper, like many other materials, has of expanding when subjected to moisture. It is also tolerably well known that the expansion is not equal in all directions, as paper, like wood, expands more in one direction than it does in another. A deal board, when wetted, expands considerably in its width, though its length is but little affected. So it is with paper when made in continuous lengths, as all photographic papers are.

This property frequently gives rise to considerable trouble in mounting photographs—particularly when two or more prints have to be joined, as is occasionally the case with large pictures when they have been printed from two or more negatives. Serious inconvenience may also arise through this unequal expansion of the paper in small portraits, by causing a distortion of the features. Two prints made from the same portrait negative, on paper which had been cut in different directions from the sheet, possessed a palpable difference in the length and breadth of the features when they were mounted wet.

Machine-made papers are made in continuous lengths, and are cut up into sheets afterwards. It has been found with nearly all samples that, when strips were cut lengthwise from the roll, the expansion, when they were soaked in water, was exceedingly small, but when cut transversely the expansion was very great; and what is of material importance in mounting photographs, it was found that strips so cut could be stretched considerably more. For example—a strip of Saxe paper 24 in. long, cut transversely from the roll, by being mounted wet and gently stretched while mounting, could be made to measure fully 25 in., and with care it could be made considerably longer. If the paper be allowed to dry after being wetted and expanded, it will contract again, but not quite to its original dimensions, though it does very nearly. Hence, if prints are required of the size of the original negative, they should be dried before mounting, and then wetted as little as possible in the operation. A solution of gelatine containing a large proportion of alcohol is recommended for the purpose. With a view to avoid the distortion sometimes existing in carte or cabinet-sized prints, when they are mounted wet and are liable to be stretched somewhat by the mounter, the same system and mountant should be employed.

(*c*) By Cowan's system, the distortion caused by the expansion of the paper, which at times becomes a serious inconvenience, is practically avoided. The method also possesses many other advantages—simplicity and cleanliness not being the least. Although the principle of cementing the print and allowing it to become dry before mounting is not new, yet the method differs somewhat from those hitherto published.

The prints, after they are taken from the washing water, are laid face downward on a plate of glass—not in a neat pile, as usual when mounting is done wet, but just as they are collected in the tank. The glass, with the adhering prints, is then reared on end to allow the superfluous water to drain away.

When the prints have drained for a short time, they are brushed over with starch paste in the ordinary manner. Each print as it is starched is lifted from the glass (by raising one corner with the point of a knife), and laid out to dry. The drying arrangement is deserving of notice, as being exceedingly convenient when large numbers have to be dealt with, or space is somewhat circumscribed.

Cowan has a number of wooden frames covered with canvas. In each corner is a screw projecting about 2 in. When one of the frames is covered with the starched prints, another frame is placed upon it—the projecting screws preserving a space of 2 in. between the two. When the second frame is filled, a third is put into position, and so on with any number of frames that may be required. The prints dry quickly on these frames, are preserved from dust while drying, and the whole arrangement occupies but little space. The starched prints also dry without curling up, which is a great convenience in the after manipulations. After the prints become dry they are trimmed, and are then ready for mounting at once, or they may be kept for any length of time (several years) without deterioration.

The method of mounting is exceedingly simple. A pile of cards is placed on the table, and the top one is then slightly damped with a clean sponge moistened with water. This card is now drawn slightly forward on the pack, and the print is then adjusted in position upon it. This is easily done as the dry starched surface has no tendency to stick to the card, as it would have if it were wet. When the print is placed in position, it is held there by a couple of fingers of the left hand, while the thumb and two fingers (slightly separated) of the right hand firmly grasp the bottom of the card together with the print. In order to prevent the print being misplaced, the thumb is pressed firmly enough to bend the card between the fingers considerably. All that now remains is to pass the print and card between the rollers of an ordinary rolling press, when the print will be found to adhere with great tenacity. Indeed, so firmly adherent is the print after having passed through the press, that it is impossible to separate it from the card without tearing. Hence, the necessity for holding the print and card firmly until they are gripped by the rollers will be apparent. So exceedingly expeditious is the process, that many dozens of prints could be mounted within the time it has taken to write this brief description. It may be mentioned that the press rollers should be nickel-plated, to avoid their becoming rusted by continued contact with the slightly moistened cards.

(*d*) So numerous are the styles in use at present for print-mounting, and so various the colours and general appearance of the mounts used, that it seems almost impossible to suggest anything new. The method to be described is particularly suitable for use with platinotype, gelatino-bromide, or other kinds of prints where the black engraving tone and effect are to be preserved, and it has the additional advantage of extreme economy.

One of the favourite methods, if not the most fashionable style at the present time, is the "plate-sunk" mount, with or without India tint—a style which undoubtedly adds a most artistic finish to prints in the popular tone. But such mounts are comparatively expensive, while those we have to recommend give a nearly equal result at a mere nominal cost, and may be "plate-sunk," if desired, with very little extra trouble.

The choice of material for the mounts may take a very wide range, though for general purposes we suggest as most suitable a slightly-tinted cartridge or drawing paper of not too rough a texture. For special or striking effects, the roughest drawing, or even wrapping papers, may be used in much the same manner as modern bookbinders adopt for catching the public eye by means of an unconventional, or even eccentric, cover. We have recently seen a series of prints so mounted on a species of drab wrapping paper of not too superlative quality.

There is, of course, one important precaution to be specially taken in using such common materials—common, that is, in the sense that they are not necessarily free from chemical impurities—namely, to either remove or in some other manner render harmless any foreign matters that may be present in the mount. Fortunately, from the nature of the mounts, as well as the process of mounting, this need not be a difficult matter. As will be seen, part of the process consists in thoroughly damping the mount as well as the print, which in the case of a solid paper does not present the same difficulties as in the case of a built-up cardboard; while the mount is undergoing the damping process, it is an easy matter to submit it to a little extra washing, or, if necessary, chemical treatment, in order to remove the impurities if such be suspected. Or the danger to the print may be at least lessened by applying a more or less impervious varnish to the mount, which, while not preventing the absorption of water, forms a protective coating when dry. Such a varnish is found in bleached lac dissolved in aqueous solution of borax; if this be applied to the paper mount before damping, it will dry without leaving any gloss, and when the mount is subsequently soaked any excess of borax will be removed, and when dry the impurities will be isolated from the print.

The method of mounting consists in immersing the mounting paper previously cut roughly to size in clean water, assuming that any necessary preparation has been already effected. When perfectly limp, the sheets are taken out of the water and, as required, blotted off between blotting-paper. The wet prints are similarly treated, and then both print and mount—the latter over such part only as the print is to occupy—well impregnated with the mountant. If the print only be treated, it will in all probability peel off at the edges on drying. Nothing answers so well for mounting as arrowroot paste made pretty thick and allowed to cool, then squeezed through fine cambric to remove lumps. It should be used fresh, as it soon becomes watery, in which condition it loses its adhesive power.

A convenient plan for applying the mountant to the centre of the mount consists in making a mask from stout, smooth paper, or perhaps better still, from thin sheet zinc of the outside dimensions of the mount with a central aperture a little larger—say $\frac{1}{8}$ in. each way—than the print. If this be laid on the damp mount, the arrowroot is easily applied to the proper portions with a sponge, and the print can be laid down in its position before removing the mask. The narrow strip of paste extending beyond the edges of the print may be removed by means of a damp sponge after the print is rubbed down; but this is scarcely needful, as it dries perfectly matt, and is only likely to show on a coloured mount.

With regard to the rubbing down, this is not so simple a matter with gelatine-surfaced papers as with albumen or platinotype; but all difficulty is surmounted by interposing a sheet of the thin paraffin-wax-saturated tissue paper sold for wrapping or waterproof purposes. This, while it adheres closely to the gelatine surface during the rubbing, comes easily away from it when it has served its purpose.

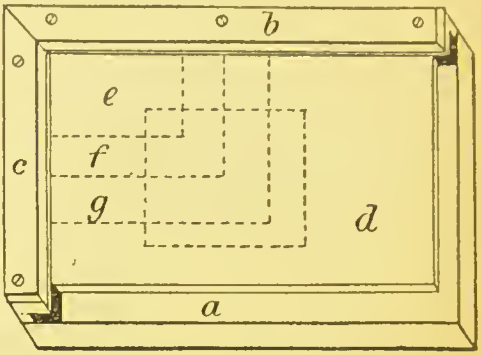
We next come to the drying, which is the most important part of the process if perfection of result is desired. It will be noticed that in order to avoid "cockling" of the dried print, the mount as well as the print has been moistened so that each may swell and shrink equally; but this is not alone effective. If left to dry alone, the edges of the mount will dry first, the extra thickness of the print-covered portion remaining damp for a considerably longer period, and taking a saucer shape from the contraction of the surrounding portions. To obviate this, the print as soon as mounted may be pinned to a flat board, or laid on a sheet of glass, and the edges of the mount turned over and stuck at the back. But by far the better plan is to have a quantity of sheets of clean blotting-paper slightly larger than the mounted prints. Let these be thoroughly dried by exposing them for some time in a hot oven, then packing in a mass, and wrapping in tinfoil until required.

The prints are allowed to become partially dry; but before they lose their limpness, or show any tendency to curl, they are taken singly and placed between the blotting-pads, at least two sheets of drying paper intervening between each pair of prints. In the case of gelatine-surfaced prints a sheet of waxed tissue paper is also necessary. If the pile of interleaved prints be now placed under gentle pressure for a few hours, they will be found perfectly dry, and as flat as if they had been rolled. It only now remains to trim the mounts to size, and, if desired, to apply a "plate mark" by giving the print a "squeeze" in a copying press between folds of paper or in the copying-book, a plate of zinc of the proper size, and with its edges slightly bevelled, being laid over the face of the print.

Such prints are equally suitable for framing, for binding, or for keeping loose in a portfolio; for the two last purposes, indeed, this method of mounting is more convenient than any others we have tried.—(*Brit. Jl. Photo.*) (See also iv. 403.)

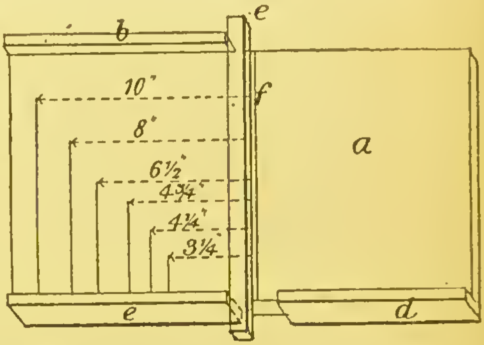
Mounting Board.—This consists of a flat board—*a* (Fig. 78), upon which are screwed the strips *b c* at right angles to one another. Each of those strips has a rabbet cut out of its under side about ½ in. deep, so as to allow the glass *d* to slip beneath. On this board a piece of paper can be pasted, on which the sizes of the mounts should be marked—*e*, *f*, *g*, &c.—care being taken that one edge and the bottom comes exactly under the edges of *b c*. *d* is a piece of glass which can be moved to and fro in the rabbets already referred to. In using this board, have the print surface dry. Put one of them on an old negative, face down, and paste; then put it on the glass *d*, still face down, and as nearly as possible to the lines. Move the glass till the print shows an equal margin all round the lines. Then take the mount, and, keeping it against the edges of *b c*, press it down, and if care has been taken, you will have a perfectly mounted print. Keep the glass dry and clean, and you will not damage the most delicate mount.—(A. Killar.)

Fig. 78.



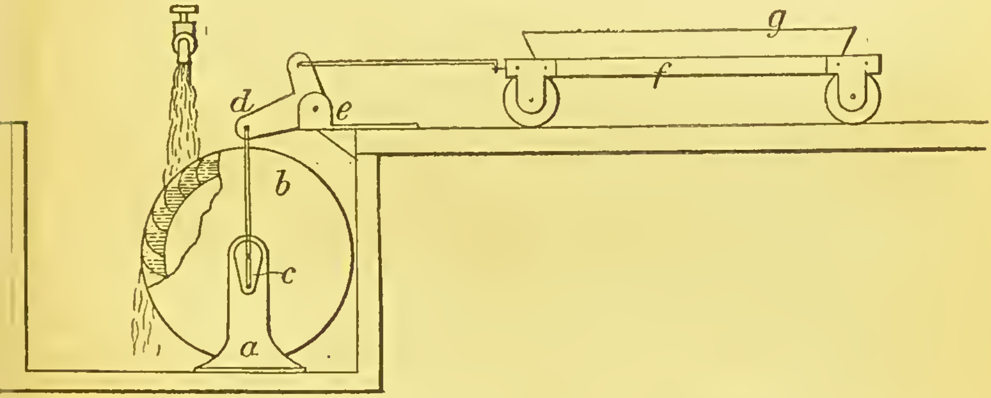
Glass Cutting Board.—*a* (Fig. 79) is a flat board, on the edges of which are screwed the projecting pieces, *b*, *c*, *d*. *e* is a piece of wood bearing against the ends of *b c*, and which forms the straight edge for the cutter or diamond. *f* is the line which the diamond will make when held against *c*. From this line the size of the plates is set out and marked on the board, or a stop is fixed, and by two cuts you have a glass exactly square, provided the board has been made square in the first instance. —(A. Killar.)

Fig. 79.



Rocking Machine. — Have a water wheel in the sink, supported on two standards, *a*. On this wheel, *b*, is fixed a crank, *c*, connected to a bell crank, *d*, supported by a bearing, *e*, which is, in its turn, connected to the carriage, *f*, supporting the developing dish, *g*, resting on four small wheels. Over the water wheel is a tap or a piece of tube, *h*, which discharges its water into the buckets of the wheel and sets it in motion. The developer in the dish, *g*, is by this means carried from end to end, and slow development is deprived of its terrors. An under exposed plate may be left in the dish for 30 minutes. This machine can also be used for toning and fixing prints, keeping them in constant motion without handling. See Fig. 80. —(A. Killar.)

Fig. 80.



Coating Paper with Gelatine Emulsions.—The difficulties in the process can be overcome by any careful, cleanly manipulator; and amateurs who will follow the directions carefully and intelligently, will have no difficulty in turning out finished prints of their own make, from beginning to end, which will meet the demands of the most exacting, and at a fraction of the cost of the commercial article. It is possible to produce prints of irreproachable purity in the whites, and velvety softness in the blacks, at a cost not exceeding 1½*d.* a piece for the whole-plate size. The formula for the emulsion is in grains to the ounce of water.

The Emulsion.

No. 1.

Gelatine (soft)	42½	gr.
Potassium bromide ..	26	gr.
Water (distilled)	1	oz.

No. 2.

Silver nitrate	32⅓	gr.
Water (distilled)	1	oz.

Dissolve the bromide first, then add the gelatine, and dissolve by gentle heat (95° to 100° F.); bring the silver solution to the same temperature, and add in a small stream to the gelatine solution, stirring vigorously, of course, in non-actinic light. Keep the mixed emulsion at a temperature of 105° F. for ½–1 hour, according to the degree of sensitiveness required, previously adding one drop of nitric acid to every 5 oz. of emulsion. Allow it to set, squeeze through working canvas, and wash two hours in running water. You can manage the washing easily enough by breaking the emulsion up into an earthen jar filled with cold water, and placing in dark room sink. A tall lamp chimney, standing in the jar immediately under the tap, conducts the fresh water to the bottom of the jar, and keeps the finely divided emulsion in constant motion; a piece of muslin, laid over the top of the jar to prevent any of the emulsion running out, completes this simple, inexpensive, but efficient washing apparatus.

The washing completed, you are ready to melt and filter the emulsion preparatory to coating the paper. When melted, and before filtering, it is well to add of glycerine and alcohol each about one-tenth of the whole bulk of the emulsion, the glycerine preventing troublesome cockling of the paper as it dries, and the alcohol preventing air bubbles, and hastening the drying. This addition made, and the emulsion filtered, you are ready to coat your paper, which may be done just as it comes from the stock dealer, plain Saxe or Rives, or better still given a substratum of insoluble gelatine, made as follows:

Gelatine	$1\frac{3}{5}$ gr.
Water	1 oz.

Dissolve and filter; then add 11 drops of a 1·50 filtered chrome-alum solution. The paper is to be floated for half a minute on this solution, avoiding air bubbles, and then hung up to dry in a room free from dust. The purpose of this substratum is to secure additional brilliancy in the finished prints by keeping the emulsion isolated from the surface of the paper. If you are floating the whole sheet, now is the proper time to cut it to the size you wish to coat, but for anything less than 6½ × 8½ cut in double or quadruple sizes, 8 × 10 for 5 × 8 and 4 × 5 prints, as the paper is easily cut down after the emulsion is dry.

Coating.—A stone, marble, or glass slab large enough to hold at least half a dozen glasses of the size paper you are coating, and most accurately levelled; a dozen or more pieces of glass of the same size as your paper; a porcelain or agate ware tray of the same size; a ruby lamp; a deep tray of a size to hold your jug of emulsion and the smaller tray; a spirit or kerosene lamp enclosed in a box suitably ventilated and protected against the egress of white light from the lamp inside (this is easily secured by punching holes around the top and bottom of a tin box of suitable size and covering it with another somewhat larger in every way, but without a top); and a goodly supply of spring clothes-pins, to be had of any hardware merchant. The above is a complete inventory of the outfit. Add a squeegee muffled with a piece of soft flannel—an article which you can easily make by procuring a piece of small black rubber tubing of the proper length and placing it in the centre of a strip of flannel of equal length and about 2 in. wide; then fold the flannel over on itself, thus inclosing the rubber tube, and fasten the whole between two narrow, thin strips of wood, drawing the rubber up close to the wood.

For coating, you must secure the temporary use of some small room in which the paper can be coated, hung up, and left to dry. This room must meet three requirements; it must be dry, free from dust, and capable of being made absolutely light-tight during the drying of the paper. Into this room, provided with a table large enough to hold your marble slab, on which the slab is carefully levelled, you carry all the articles mentioned above. The spirit or oil lamp is placed in its box, on which stands the large tray previously filled with water at 100° F., and containing the jar of emulsion and the small tray filled with warm distilled water. The ruby lamp stands on a table in front of you; the glasses, well cleaned and warmed to blood heat, and the paper with the side to be coated uppermost are placed on the table at your right; within convenient reach of your right hand stands the tray of warm water, and the levelled slab is within easy reach on your left. Turn the ruby lamp down as low as is consistent with the power of vision. Now immerse a sheet of the paper in the water in the small tray, leaving it there for a minute or two; then place it accurately on one of the glass plates, and sweep off all superfluous water with the squeegee, at the same time removing all wrinkles and air bells, and place in an upright position to dry slightly while you prepare a second plate in the same manner. Now balance the first plate on the tips of the fingers and thumb of the left hand, and pour on a sufficient quantity of the emulsion, about 1 dr. for every 10 sq. in. of paper. You can use a silver soup ladle holding just enough to cover a whole plate. Gently tilt plate from you until the further end is completely covered; then as gently tilt it toward you until the emulsion completely covers the paper; then carefully place it on the levelled slab to set. Continue this operation until the slab is covered, when the paper first coated will probably have become sufficiently set to be stripped from the glass and hung up by clothes-pins to dry, requiring 6–10 hours.

The exposure is somewhat long. With negatives of ordinary density, and a kerosene lamp with a 1½ in. wick, 1–1½ minutes is about right, the negative being held about 18 in. from the lamp. Considerable latitude of exposure is given by this process, which is a great advantage. The developer is ferrous oxalate, in the proportion of 1 part of iron to 5 or 6 of oxalate, adding more iron occasionally to strengthen. Both the iron and oxalate solutions should be kept slightly acid; use no bromide, which ruins the tone and diminishes detail. Of course, the acid clearing solution—1 dr. acetic acid to 32 oz. water—should be used.

Negative paper is prepared in the same way, substituting a more rapid emulsion for the slow one given above.

It may be worth noting that very good matt surface prints can be made by coating ordinary drawing paper of light or medium weight with this emulsion, but for contact printing from small negatives the results are rather coarse. —(R. W. Burbank.) (See also iv. 344.)

Collodio-Chloride Positive Printing Paper.—The advantage of this paper over the ordinary silver paper is that it is 5–6 times more rapid, is more brilliant, and very readily toned to any desirable colour. Any suitable paper of a firm texture can be used, but it is preferable to employ special Saxe or line plain photographic paper, or, instead, chalk paper used for Lichtdruck purposes. The paper is first coated with a weak solution of gelatine and water, 5 gr. of gelatine to each oz. of water, and then dried. It is next coated with a sensitised collodion emulsion, made after the formula devised by F. W. Goldmacher, as follows:—"The preparation of this silver chloride emulsion demands, in the first place, chemicals of the utmost purity, and a strict observance of the order in which the different compounds are made. A 2 per cent. collodion will answer if the coating of the plate is proceeded with slowly. With 3 per cent. of cotton and the addition of ½ per cent. of castor oil, the film is stronger and more tenacious.

Ordinary plain collodion sold by dealers in photographic materials will answer, but should be diluted with ether to the proportions above stated.

Three separate solutions are now prepared as follows:—

No. 1.

Silver nitrate	20 grm. (308 gr.).
Water	20 cc. (5 dr.).
Alcohol	50 cc. (12½ dr.).

If, with the addition of the alcohol, a recrystallisation of the silver nitrate should take place, the whole mixture must be placed in a warm water bath to be kept in solution.

No. 2.

Citric acid	5 grm. (77 gr.).
Alcohol	70 cc. (2¼ oz.).

No. 3.

Strontium chloride ..	5 grm. (77 gr.).
Alcohol	70 cc. (2¼ oz.)

Besides the strontium chloride, other chlorides may answer as well. Calcium chloride causes higher sensitiveness, but collodion prepared with it prints violet, while strontium proofs are more of a reddish tone, which allows a more correct observation in the subsequent toning process. A reddish tone allows us to see more distinctly the action of the gold bath. The citric acid solution (No. 2) is mixed with chloride solution (No. 3) and the whole added to 800 cc. (25 fl. oz.) of plain collodion. This chlorated collodion can now be sensitised by adding the silver solution (No. 1) very gradually and by frequent agitation, by a subdued light (gas or lamp light). The emulsion should be filtered through a thin layer of cotton, after standing a few hours. But as the silver chloride is held in suspension, the bottle should be vigorously shaken just before filtering, in order that the particles of silver may pass through. Shaking the bottle prior to coating is also necessary.

The paper is stretched on a board, and clamped by a light frame around the edges. The collodion is then poured on near one corner, and by giving the board a series of movements with the hand, the collodion gradually flows over the entire surface (similar to the coating of a glass plate with collodion), while the surplus is drained off at the opposite corner into a separate bottle. A special hole or niche should be provided in the lower corner of the frame to allow the collodion to easily flow off.

It is also better to use a thin collodion, and recoat the paper two or three times, running off the collodion of subsequent coatings at the opposite corner from that of the previous coating, which tends to produce a very even film. Paper coated very heavily is apt to roll up in the water in a very objectionable manner, and will crack when drying. By bending the edges of a sheet of paper over a glass plate, the paper can be very readily coated. It is also advisable to add additional alcohol and ether occasionally to the collodion, to replace that evaporated by frequent lifting of the stopper.

The paper must be dried in a well ventilated room. Dampness is very injurious. Quickly dried paper is also more sensitive, and prints with more brilliancy. It is preferable to cut the paper with a dull pair of scissors than with a knife, as there is less danger of injuring the film.

The prints should be washed before toning sufficiently to take off the surplus silver.

An ammonia sulphocyanide gold bath without the addition of soda hyposulphite answers best for toning, and the latter operation proceeds very smoothly, provided the paper is not too old. If kept longer than a week, it is liable to tone very irregularly.

A great variety of tones can be obtained, from a pronounced red to a distinct blue, according to the length of time the print is kept in the bath.

Goldmacher advises the following proportions for a toning bath:—

Gold Solution.—Gold chloride, 1 gr. water, 200 cc. (6 oz.).

Sulphocyanide Solution.—Ammonium sulphocyanide, 10–20 gr.; water, 500 cc. (15½ oz.).

The gold solution is now added to the above, when a red precipitate will occur, which, however, redissolves in a few days. When perfectly clear, the solution is ripe and ready for use; 55 cc. (1½ oz.) of it put into 5 parts of water will tone one sheet of 18 × 22 paper. If the sulphocyanide solution is made strong, the tones will be warmer; if weak, then they will become more violet or blue. An old bath used several times produces fine sepia tones.

After toning, the print is slightly rinsed, and is then immersed for 10 minutes in an alkaline fresh fixing bath:—Soda hyposulphite, 1 oz.; water, 30 oz.

The bath may be made alkaline by the addition of a little ammonia.

After fixing, the prints should be washed for 3 hours in several changes of water.

Owing to the delicate character of the collodion film, and its liability to be defaced, it is necessary that the greatest care be exercised in the manipulation of the paper.

Liesegang has suggested the application of this collodion film to wood, porcelain, &c., in the following manner:—First, a sheet of smooth gummed commercial paper is flowed with the emulsion, as previously described, the print is made, but not toned and fixed. It is then transferred from the paper to any desired support. The wood, porcelain, &c., on which the print is to be transferred is previously coated with a thin film of gelatine. The print—in a wet condition—is now squeegeed on to the porcelain, or other support, and the whole is soaked in water at the ordinary temperature for 5 minutes, or until the gum coating between the collodion film and paper softens sufficiently to allow the paper to be easily pulled off. We then have a transparent film left on the porcelain. The picture is toned, fixed, and washed on its new support in the usual manner.

A reversed position will be given to the picture, but this will be of no consequence when it is used as a transparency or a lantern slide.—(S. C. Passavant.) (See also iv. 378.)

Silver Prints on Rough Drawing Paper.—Cut rough drawing paper into convenient sizes, and coat each piece on one side, by floating, with a warm solution of gelatine, made by dissolving sheet gelatine in the proportion of 4 gr. to 1 oz. of water and 5 gr. of sodium chloride. After drying spontaneously, the paper is ready for use at any future time.

The sensitising is a very simple and easy process, and a sheet may be got ready for the printing frame within ¼ hour. Fasten the paper by pins at two corners, with the prepared side uppermost, on a board slightly smaller each way than the sheet, and place this in a sloping position. Pour a small quantity of the sensitiser into a small vessel, such as a wineglass or an egg-cup, and, with a brush well filled with this solution, coat the paper by applying it in transverse strokes, commencing at the top, and working downward. When coated, bring the paper to a vertical position, and suspend it by one corner, attaching a fragment of dry blotting paper to the lower corner to absorb the superfluous liquid. The drying of the paper may be expedited by holding it in front of an ordinary fire. The printing should be carried considerably beyond the strength ultimately required, as much is lost in toning and fixing.

To make the sensitising solution, dissolve 60 gr. of silver nitrate in 1 oz. distilled water, and add carefully drop by drop, and with shaking, strong liquor ammoniæ, until the solution, which at first becomes muddy, just clears again. If this stage is accidentally passed, add a trifle more silver.

It is obvious that a brush set in metal would be unfit for this process, but one which is thoroughly efficient and presents the advantage of being renewable for each operation is that known as a Buckle brush (from the name of its inventor), made by taking a piece of glass tube say 8 in. long and ½ in. diameter, and drawing into one end of it, either with a piece of silver wire bent to form a hook, and long enough to pass through the tube, or with a piece of string, a tuft of cotton wool, the fibres of which have been drawn out lengthwise, the wire or string passing round the middle. When the cotton wool is partially drawn into the tube, where it should fit tightly, it may be pulled into shape, and will be found an excellent tool for the purpose.

A toning bath made with gold chloride and soda bicarbonate is best suited for this paper, and with this, if the toning is carried far enough and the negative is a good one, black tones, rivaling platinum, may be obtained.

This mode of printing is well adapted to bold and vigorous subjects, and, as the paper does not curl, the pictures may be printed with deep wide margins, rendering mounting unnecessary; the beauty of the photograph being, at the same time, much enhanced by the coarseness of the texture of the white paper.—(J. H. Biggs.)

Relief or Printing Plates.—Joyce Process.—Take a smooth metallic plate, covered with a thin coating of clay, plaster, or equivalent material applied in a plastic state.

Employ a mixture of ground potters' clay and plaster of Paris, nearly equal parts, moistened with water to the consistency of mortar; but ground soap-stone, chalk, or other material may be used instead.

The material is spread upon the metal plate and scraped down to any desired thickness, accordingly as lines are required in high or low relief, the thickness of the coating determining the relief elevation of lines in the finished plate.

Usually dry the plaster coating before any portion is cut away, but this is not essential.

Design may be pencilled, traced or transferred upon the surface of the plaster, or an artist sufficiently skilled may work without any copy. The coating is then cut away for the lines, entirely through to the metallic plate.

Points, needles, gravers, &c., may be used for cutting or scratching away the material. When the design has been completed, the lines are cleaned out with a soft brush, or blown out with a bellows.

The plate at this stage of the operation resembles a mould for a stereotype plate as used in the clay or plaster process of stereotyping, except that the lines and letters are cut entirely through the plaster.

The mould or matrix is now made ready, and a metal stereotype plate is cast upon it in any manner usual in the stereotyper's art. This plate is finished up in the ordinary manner, and if more relief is desired for the lines, the low portions of the plate may be cut or routed out.

Door plates and other ornamental relief line plates may be made in the same manner.

Relief line plates can thus be made in a very short time. It is especially adapted for the speedy reproduction of plates for maps, diagrams, plans, &c.

Hoke or Star Process.—The base plate of the engraving plate for stereotyping purposes is preferably a polished blued steel plate of suitable superficies. It withstands the heat incident to stereotyping, and its tint, when a light-coloured coating is used, presents a marked and agreeable contrast to the coating, and enables the engraver to readily judge the effect of his work. For electrotyping purposes, a base plate of glass is preferred. Glass is also an excellent material in combination with the special coating, and its transparency enables the engraver to examine his work by holding the plate to the light.

For the coating of the plate a finely powdered inorganic substance which will withstand the heat of molten stereotyping metal—is used. The more thoroughly and evenly the material is comminuted, and the more marked the contrast in colour between the coating and the base plate, the better is the engraving plate adapted for the purpose in view.

The leading features are that the particles of the coating next to the base plate adhere thereto more strongly than the particles above them adhere either to them or to each other, and that the coating is very friable and the particles very loosely as well as very evenly bonded together, so that they readily separate without caking and without breaking away between the lines when the plate is engraved; bonding the particles of the coating to each other and to the base plate with soluble glass or an equivalent soluble mineral alkaline bond; bonding the particles of the coating to each other and to the base plate by treating the particles with a solution of soluble glass, and then baking the coated base plate until the coating is dried; mixing together the ingredients to be bonded, then adding a water glass in solution, and then subjecting a base plate coated with the mixture to a heat beneath the boiling point and not under 100° F. until the coating is solidified, after which the heat may be increased without injury to the coating; the special combination of substances given in the formula is used to form the coating upon the base plate.

In engraving a design in the matrix, it is highly desirable that the engraver shall be able to see distinctly the lines made through the coating, and thereby judge correctly the work being done. To this end the coating is made white or light-coloured, while the surface of the base plate appears dark, and the end is more effectually attained by employing a blued steel plate for the base plate.

The coating consists of 2 dr. barium sulphate (barytes), 2 dr. magnesia silicate (French-chalk), $1\frac{1}{4}$ dr. soda silicate, 4 drops water. This mixture will cover sufficiently thick 6 sq. in. of plate.

The more perfectly it is mixed, the better the plate. A good way to make the mixture is first to mix the earth with water, and work and rub the ingredients in a mortar until the mixture becomes smooth, and then add the solution of soluble glass and mix it with the other ingredients as thoroughly as practicable. The mixture should then be spread evenly over the base plate, shaking it slightly to settle the coating evenly. The coating should, after being placed on the plate, be dried by heat, preferably between 180° and 190° F., until it solidifies, after which the heat may be increased as high as 300° F. without injury to the coating. The object in keeping the heat beneath the boiling point while the coating remains in a semi-liquid state is to prevent its boiling. The coating should be thoroughly dried. The coating at its top is usually incrusted, and after the plate has cooled and before it is engraved, the crust should be scraped off, and the coating made of a uniform depth over the surface of the base plate.

When the coating is mixed very slowly, it may be baked at once; but otherwise it should be allowed to stand after mixing for at least 5 minutes before baking, and is rather improved by being allowed to stand longer. The object is to allow the air contained in the mixture to escape as far as possible, and to prevent the coating from curling up and cracking while being dried.

The above method of mixing and baking is not the only one that can be used. The essential points are first to introduce the bond in the form of a solution into the body of the coating, and then to dry the coating upon the plate.

Instead of mixing the bond with the water and earths in the manner above described, the mixture may be made without the bond, and dried, with or without artificial heat, upon the base plate, and the coating may then be saturated with a solution of soda silicate containing 25–50 drops of soda silicate to 1 oz. water, and then baked as first above directed.

The formula above given may be widely departed from and good results still obtained, so long as the bond is of the proper nature and is used in the proper proportion. Either magnesia silicate or barium sulphate may be used alone in place of the mixture, though not so good. Barium sulphate is somewhat undesirable when used alone, because a coating made of it has a tendency to crack in drying.

All kinds of light-coloured earths may be used. Those which have the least attraction for water are the best. The clays are perhaps the least desirable of all, because of their tendency to crack when drying. It is desirable where they are used to mix them with an equal bulk of plaster of Paris or with some other substance which will prevent cracks, as the bond will not perform that function when used in the proper proportion.

The most desirable earths—naming them in their order of merit—are soapstone, tripoli, talc, quartz, and chalk. Barium sulphate, though excellent when mixed with magnesia silicate, is not so good when used singly. Mixing a very light with a very heavy earth is a good course to follow. The specific gravity of a mixture of barium sulphate and magnesia silicate in the proportions named is the most desirable.

Where less than two drops of bond are used, the plate is very poor, because insufficiently bonded. Where more than eight drops are used, the coating is made too hard to be entirely satisfactory, and is more or less liable to break away from the base plate when being engraved.

A test as to the amount of water to

be used is that the mixture when made should be thin enough to pour out of a containing vessel, but no thinner than necessary for that purpose. It should be of about the consistency of batter, so that a small portion will cling to the side of the vessel from which it is poured. Clay is an exception to the general rule as to the amount of water necessary. Where it is used, only one-half the quantity of water necessary for other substances should be used.

Hansen Process. — (*a*) Provide a smooth level plate of some suitable hard material and of a size somewhat exceeding that of the engraving which it is desired to produce. A piece of plate glass will answer admirably. The face of this plate is covered with a thin coating of tallow, lard, oil, or beeswax, spread evenly and enabling a sheet of tinfoil to adhere to the composition with such tenacity as to prevent it from being displaced when manipulated.

The tinfoil, having been attached to the composition on the plate, is ready for the draughtsman or artist, who, with a style, pencil, or other instrument, proceeds to draw the sketch of which an engraving is required, taking care to exert sufficient pressure to indent the tinfoil to the depth of the base plate, the intervening layer serving to give depth and tone to the lines, which may be made fine or coarse by using suitably pointed tools. In this manner letters may be written and sketches or drawings executed very rapidly and with great facility.

The next step is to place the prepared plate in a level position and to pour over it a quantity of plaster of Paris, of which the matrix over which the stereotype or electrotype afterward to be made is formed. As soon as the plaster is sufficiently hardened or set, the matrix is removed from the bed plate. This may be easily accomplished by slightly heating the under side of the plate, thus melting or softening the intervening layer, when the tinfoil, with its plaster backing, may be readily removed.

The face of the matrix (which is formed by the tinfoil) is now washed with benzine, turpentine, or other material, for the purpose of removing any portion of the intervening substance which may still adhere, and the matrix is now ready for stereotyping or electrotyping.

By drawing in the tinfoil with suitable tools, lines may be obtained as clear and sharp as the finest line engraving, the intervening layer serving not only to hold the foil upon the bed plate, but to give depth, tone, and richness. Its thickness may therefore be varied to suit circumstances.

To obtain correct likenesses of individuals, scenes from nature, &c., such likenesses are to be photographed upon the tinfoil, to serve as a guide for the draughtsman, whose task is thus reduced to a mere mechanical one.

By this process printing blocks of any subject may be produced with great rapidity and accuracy, and at a trifling expense.

(*b*) First, provide a bed or base plate of steel or other suitable material that will resist heat, the top of which should be polished smooth and placed in a perfectly level position. Next, provide the plate with a coating of plastic material which will resist heat—such as slaked lime, kaolin, or tripoli, which, when mixed with a suitable quantity of water, will form a plastic composition which may be spread evenly upon the top of the plate to form a coating of uniform thickness, and which will not melt or "run" by the application of heat.

The next step is to carefully cover the coating with a layer of foil which will not melt at the temperature where type-metal melts. Thin copper foil is well adapted for this purpose, and this should be provided with a thin film or coating of tin or solder. As thus prepared, the base plate is ready to receive the engraving by indenting the foil, down through the layer of plastic material, to the base by means of a stylus or other suitable instrument, according to the figure, sketch, or lettering which it is desired to represent in the engraving. The plastic layer operates to give depth and tone to the lines, which may be made fine or coarse by using different kinds of tools; and it will readily be seen that as the engraver has soft and yielding material to work in, the engraving, or rather indentation, may be executed with great rapidity. The plate having been prepared, the thin film or coating of foil is carefully moistened with muriatic acid, to prepare it to receive and firmly adhere to the type-metal backing. The plate is placed in a frame, after which a quantity of molten type-metal is poured over the foil to form a plate or backing of the desired thickness. The type-metal, as it flows freely over the foil film, unites therewith without disturbing in the least the underlying foil or coating, and after hardening, the plate or relief block thus formed is removed from the coated base plate and is ready for use, after washing its face to remove any trace of the coating material, and suitably finishing the back.

Photo. Printing Plates.—The drawing intended for reproduction is pinned on a board and placed squarely before a copying camera in a good, even light. The lens used for this purpose must be capable of giving a perfectly sharp picture right up to the edges, and must be of the class called rectilinear, i. e. giving straight lines. The picture is then accurately focussed and brought to the required size. A plate is prepared in the dark room by the collodion process, which is then exposed in the camera for the proper time, and developed in the ordinary way. After development, the plate is fixed and strongly intensified, in order to render the white portions of the drawings as opaque as possible. On looking through a properly treated negative of this kind, it will be seen that the parts representing the lines and black portions of the drawing are clear glass, and the whites representing the paper a dense black.

The negative, after drying, is ready for the next operation, i. e. printing upon zinc. This is done in several ways. One method will, however, be sufficient for the purpose here. Obtain a piece of bichromatised gelatine paper and place it on the face of the negative in a printing frame. This is exposed to sunlight (if there is any) or daylight for a period of 5–30 minutes, according to the strength of the light. This exposed piece of paper is then covered all over with a thin coating of printing ink, and wetted in a bath of cold water. In a few minutes the ink leaves the white or protected parts of the paper, remaining only on the lines where the light has passed through the negative and affected the gelatine. We now have a transcript of the drawings in printing ink, on a paper which, as soon as dry, is ready for laying down on a piece of perfectly clean zinc, and passing through a press. The effect and purpose of passing this cleaned sheet of zinc through the press in contact with the picture on the gelatine paper is this: Owing to the stronger attraction of the greasy ink for the clean metal than for the gelatine, it leaves its original support, and attaches itself strongly to the zinc, giving a beautifully sharp and clean impression of the original drawing in greasy ink on the surface of the zinc. The zinc plate is next damped and carefully rolled up with a roller charged with more printing ink, and the image is thus made strong enough to resist the first etching. This etching is done in a shallow bath, which is so arranged that it can be rocked to and fro. For the first etchings, very weak solution of nitric acid and water is used. The plate is placed with this acid solution in the bath, and steadily rocked for 5–10 minutes. The plate is then taken out, washed, and again inked; then it is dusted over with powdered rosin, which sticks to the ink on the plate. After this the plate is heated until the ink and rosin on the lines melt together and form a strong acid-resisting varnish over all the work. The plate is again put into the acid etching bath and further etched. These operations are repeated five or six times, until the zinc of the unprotected or white part of the picture is etched deep enough to allow the lines to be printed clean in a press, like ordinary type or an engraved wood block. After each etching the plate is thoroughly inked, and this ink is melted down the sides of the line, so as to protect the sides as well as the top from the action of the acid; were this neglected, the acid would soon eat out the lines from below. The greatest skill and care are necessary in this work, especially in the case of exquisitely fine blocks which are etched for art publications.

After etching there only remain the trimming of the zinc, a little touching up, and mounting it on a block of mahogany or cherry of exact thickness to render it type high.—(G. S. Waterlow.)

Gelatine Argentic-Bromide Emulsions and Plates.—The formulæ, apparatus, and mode of working described are those which experience has found to be useful and practical. Any person, by following these directions, may succeed in making for himself excellent rapid dry plates.

As a general rule, prepare the emulsion in the evening, and the formulæ to be given should make 22 oz. of finished emulsion, with which 54 6½ × 8½ glass plates may be coated.

The emulsion should be mixed by a non-actinic light, say, in the form of a good-sized lantern, 6 in. square by 10 in. high, having inside a kerosene lamp with a long chimney. The front and sides are glazed with one thickness of ruby glass, the front pane being covered with one, and the side panes with two thicknesses of yellow orange post-office paper. When preparing the emulsion, or coating plates, the light is turned up only to half its full height. The lantern is fixed on a shelf 1 ft. above the table and about 3 ft. from the place of mixing or coating.

First make the following two solutions:—

No. 1.

Potassium bromide	20 grm.
Gelatine, Nelson's No. 1 ..	3 grm.
Potassium iodide	4 gr.
Distilled water	170 cc.
Alcohol, 95 per cent.	25 cc.

No. 2.

Silver nitrate	25 gr.
Distilled water	170 cc.

On the following evening make as follows:—

No. 3.

Heinrichs' special gelatine ..	34 gr.
Nelson's No. 1 gelatine ..	4 gr.
Distilled water	180 cc.

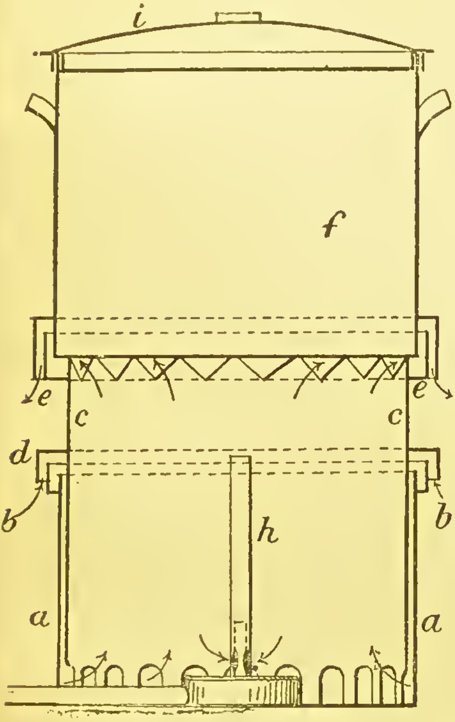
Each of the above solutions may be prepared separately, in ordinary light. Solution No. 1 is placed in a water bath of warm water, and constantly stirred with a glass rod; when all the ingredients are completely dissolved, it is tested with blue litmus paper for acidity; if not acid, it is made so by the addition of enough of the following to turn the litmus slightly red:—

Distilled water	5 dr.
Acetic acid	1 dr.

The first apparatus that is necessary is a good heating arrangement for raising the temperature of the solutions. Fig. 81 is a sectional view of the heater. The outside cylinder *a* is made of sheet iron, and riveted at its upper end is an upwardly projecting air-inlet flange *b*. Sitting inside the outside cylinder *a*, with its upper and lower edges escalloped or serrated, is an inside cylinder *c*. A downwardly projecting air-inlet flange *d* is riveted to the outside of cylinder, so that it projects just over the flange *b* on cylinder *a*. A second upwardly projecting inlet flange *e* is riveted to the upper end of cylinder. Resting on the upper edge of the cylinder *c* is an ordinary metal boiler *f*, having a downward projecting inlet flange *g* at the bottom, which overlaps the flange *e* on the cylinder *c*. The cover of the boiler has projecting flanges, making a light-tight joint when placed in position.

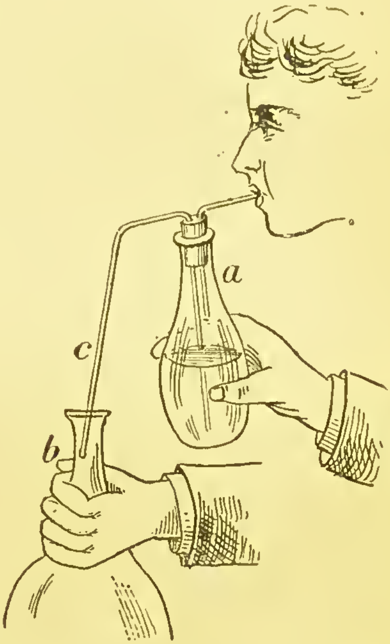
Inside the cylinder *c* is put a Bunsen gas burner or kerosene lamp *h*, a close joint being made where the supply tube passes through the outside cylinder *a*. It will be seen that the above construction permits of the burning of the gas or lamp in a dark room without danger of the light escaping. All the projecting flanges must be blackened on the inside. In place of the boiler *f* a smaller and more shallow boiler may be put on, to be used as a hot water bath, which will be found necessary to keep some of the solutions at a uniform temperature. The air to supply the burner *h* passes between flanges *b* and *d*, down between cylinders *a* and *c*, through apertures at the bottom of the latter, as shown by the arrows, while the heat escapes at the top of cylinder *c*, between flanges *e* and *g*.

Fig. 81.



Three quarts of cold water are put into the boiler *f* (Fig. 81), which should be at the boiling point by the time solutions Nos. 1 and 2 are prepared. The boiler is next removed, and in its place is put the smaller boiler or water bath. In a 10 oz. glass beaker is placed solution No. 1, and in the flask *a* (Fig. 82) solution No. 2, the cork and tubes having been removed. The beaker and flask are next placed in the shallow water bath, and enough cold and hot water from the boiler is poured into the bath to surround them without danger of floating or upsetting, the temperature of the water being no higher than 110° F. From the lamp underneath, the temperature of the surrounding water is gradually raised until, by a thermometer immersed in solution No. 1 in the beaker, a temperature of 155° F. is indicated.

Fig 82.



The whole apparatus and operations should now be transferred to the dark room.

The water bath, with the beaker and flask in it, is now removed from the heater, and set upon a table, the boiler previously removed is again returned to the heater, and the water in it is left to boil, while the following is being done:—

The cork and bent glass tubes are inserted in the flask *a* (Fig. 82), then the No. 1 solution is poured from the beaker into a second 24 oz. flask *b*, and in it is inserted the pipette tube *c* of flask *a*. Holding flask *b* by the neck in the left hand (Fig. 82), the operator by blowing through the tube forces the silver solution in a fine stream into the bromide solution until the flask is emptied. The flask *b* is continually rotated by the left hand, while the flask *a* is steadied in a water bath by the right hand. The constant agitation of the No. 1 solution in flask *b* is necessary during the injection of the silver solution, in order that the silver may be completely converted into bromide. The cork and tubing are next removed from flask *a*, and the latter is rinsed with 20 cc. of distilled water, which is added to the mixed emulsion in the flask *b*. A piece of clean cloth is tied over the mouth of the latter, and it is then placed in the boiler, the water in which is at the boiling point. The cloth over the mouth of the flask prevents the water of condensation in the boiler from dropping into the flask. The cover *i* (Fig. 81) of the boiler is now put on, and the flask is left in for 20 minutes, the cover being removed every 6–7 minutes, so the flask may be shaken each time for 20–30 seconds during the 20 minutes the emulsion has to boil.

The flask is next removed from the boiler, and the emulsion is poured from it into a quart stone bottle (an ordinary stone porter bottle will answer); the flask is immediately rinsed with 20 cc. of distilled warm water, and the latter is added to the emulsion in the stone bottle. The bottle is corked and put under a stream of cool water until the temperature of the emulsion is reduced to 85°–90° F., but it must not exceed 90° F.

After the emulsion has cooled down to 85°–90° F., the bottle is removed and the following solution—

Alcohol	5 cc.
Ammonia (sp. gr. ·910)	105 m.

is added, a little at a time, vigorously stirred, the bottle being shaken up after each addition.

The water in the boiler *f* (Fig. 81) must not now be warmer than 100° F., and after putting in the bottle, which must be nearly covered with the water, the gas flame should be turned down low.

It will now be necessary to tie the cork down, else it will be liable to be forced out, thereby damaging the emulsion, for we may now remove the lamp from the lantern and work by a strong light. The bottle is now replaced in the boiler *f*, the water in which must be kept at a temperature of 100° F., and the bottle allowed to remain there 30 minutes. The light below is next extinguished, and the bottle is kept in the boiler till the next morning. It is then removed and vigorously shaken for 2–3 minutes. This should be repeated 7 or 8 times for a period of 12 hours.

During the day, while away from home, have some one at home to do the shaking. Returning in the evening, prepare No. 3 solution in a 12 oz. glass beaker, setting it into a water bath at a temperature of 125° F., and while preparing the above and dissolving it, the bottle of emulsion is also set into another water bath, at a temperature of 90° F. When No. 3 solution is dissolved, it is cooled down to 100° F., and added, 2 oz. at a time, to the warm emulsion in the stone bottle, the latter being well shaken after each addition. This must be done by ruby light.

As soon as all of No. 3 has been added, the bottle is well shaken, and the emulsion is poured into a 2 lb. gallipot (an article which can be obtained from almost any druggist); the cover is put on, and it is left standing for 10 hours, or until the next morning, when it will have solidified into the form of a jelly. To remove it from the pot, pour in upon the jelly a few ounces of water; then with a glass rod loosen the cake of jelly from the inside by running the rod around between the jelly and the interior surface of the pot. When the pot is turned over, the emulsion jelly comes out in one cake and falls into the well, *a*, of the squeezing press, Fig. 83, falling on a silver plated copper wire net *b* at the bottom (see the full

Fig. 83.

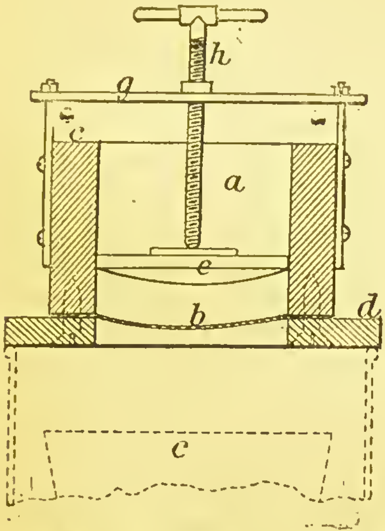
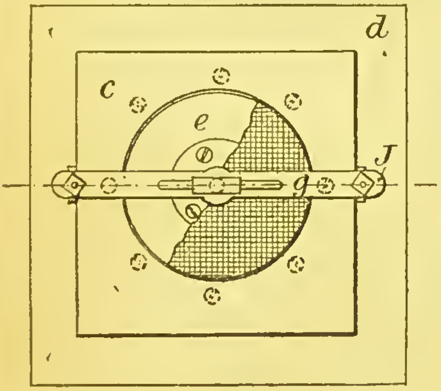
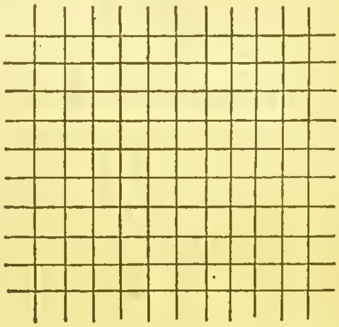


Fig. 84.



size of the meshes in Fig. 85). By means of this press the emulsion is forced through the netting into the washing wood bucket *c* below (see Fig. 88), having a piece of canvas, such as is used by ladies in making worsted work, tied over the open bottom. The bucket is supported by flanges on the interior of the washing box *a*, Fig. 88, and in one side of the latter is a siphon tube *b*. The stratum of emulsion seen in the bottom of the bucket *c* (Fig. 88) is washed for an hour or more by allowing the water to enter from above in a gentle stream, about as fast as the siphon draws it off. By stopping the inflow the siphon will drain out all the water. The cover *d* of the washing box has a conical-shaped aperture in the top for the rubber cork holding the inlet tube; when this tube and cork are withdrawn, the extra cork *e*, hanging by a string at the side, is put in. *f* is a sink placed near the table for carrying off the waste water. The washed emulsion should now be tested for fog, which is done by taking two 3 oz. beakers, putting into one 1 oz. of developer prepared for developing a plate, and in the other 1 oz. of water.

Fig. 85.



With a silver spoon, a small quantity of the washed emulsion is taken from the bucket *c* and dropped into each of the beakers. If it is a pyro developer, it is allowed to stand for two minutes; if ferrous oxalate, 5 minutes; then the developer is thrown off and the emulsion is rinsed in three changes of distilled water, and both samples, the one that had the developer on and the one without, are taken as soon as possible to daylight and compared; if this is not done promptly, they will change colour very quickly. If the emulsion that had the developer on does not look in any way blackish, or show any change, it proves that it is perfect, and will do to coat plates with. If, on the other hand, there is a perceptible difference in colour between the two, it will be a sure sign that the emulsion is defective, and the quickest way to dispose of it will be to throw it into the waste and prepare afresh another batch.

If the emulsion is right, it is left to drain in the bucket for 8–9 hours, or from morning to night, then the bucket is removed and placed upon 5 or 6 sheets of thick blotting paper, previously soaked in 4 or 5 changes of hot water and afterwards dried to free it of hypo. The netting at the bottom of the bucket comes directly in contact with the paper, and as soon as a sheet is wet it is removed and replaced with a fresh one. The emulsion is worked over with a silver spoon, so as to bring new surfaces toward the blotters.

Fig. 86.

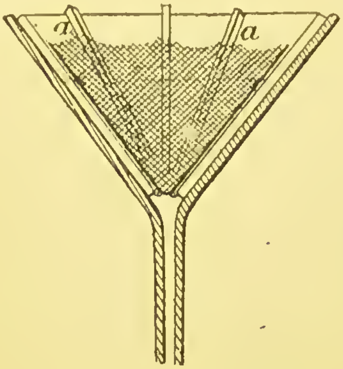


Fig. 87

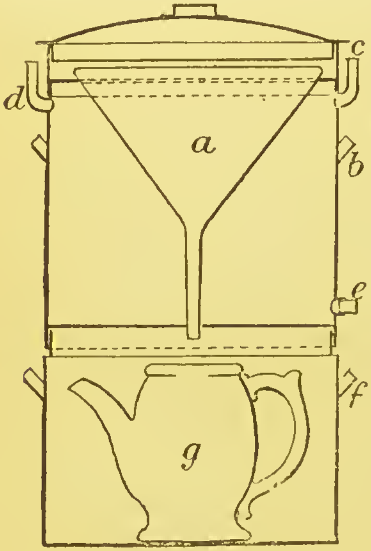
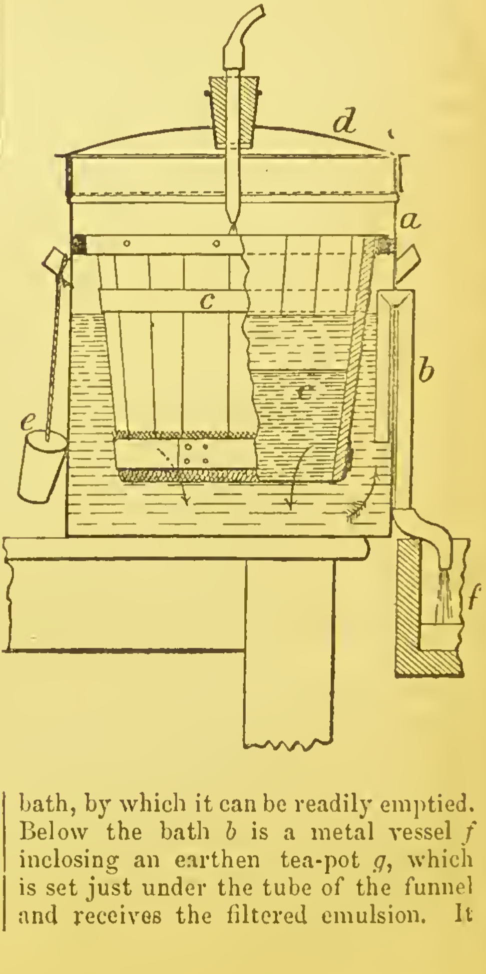


Fig. 88.



After all the water has been absorbed, the emulsion is transferred from the bucket to the gallipot (which in the meantime has been very well cleaned) and is melted by immersing the pot in a water bath having a temperature of 135° F.; 20 cc. of alcohol are now added to the emulsion, and as soon as it is melted it should be filtered as shown in Fig. 86, through Canton flannel, with the smooth side outward or against the glass of the funnel, and elevated from the surface of the funnel in convolutions or folds by strips of glass *a*, ½ in. wide. In Fig. 87, the funnel *a* is set into a funnel-shaped receptacle or seat formed of tin in the interior of the water bath *b*, the water in which is at a temperature of 130° F. *c* represents an inlet tube for water, and *d* is an outlet tube for steam, *e* is a cork at the bottom of the bath, by which it can be readily emptied. Below the bath *b* is a metal vessel *f* inclosing an earthen tea-pot *g*, which is set just under the tube of the funnel and receives the filtered emulsion. It usually takes about 10 minutes for 22 oz. of emulsion to filter through.

In the construction of the press, *c* (Fig. 83) is a block of hard wood, 8 in. square by 5 in. deep, having a hole 6 in. diameter, bored through and highly polished. *d* is a hard wood board ½ in. thick by 11 in. square, having a hole 6½ in. diameter in its centre. The piece of wire netting *b*, 9 in. square, is clamped between *c* and *d*, which are fastened together by several screws. Fig. 84 shows a plan and the position of the screws. *e* is a wooden piston, 5¾ in. diameter and 1 in. thick, slightly curved on its lower face to correspond with wire *g*, and on its upper face is a metal plate, 2 in. diameter. Secured on each side of the block *c*, are two metal uprights *f*, having a shoulder at the top, on which rests the cross bar *g*, which is held in place by suitable screw nuts on the extremities of the uprights as shown. The screw shaft *h* passes through the nut in the cross bar *f*, and as it is rotated to the right, the piston *e* is forced downward.

In operating the press, the small nuts holding the cross bar *g* in place are unscrewed, then the bar and screw are lifted out and also the piston *e*. The jelly emulsion is then put in the well *a*, the piston *e* is placed on top of it, and after that the screw shaft *h* and cross bar *g*. As the piston *e* is forced down by the screw shaft, the emulsion is easily and quickly squeezed through the wire cloth.

The plates, prior to coating with the filtered emulsion, are coated with a substratum of:

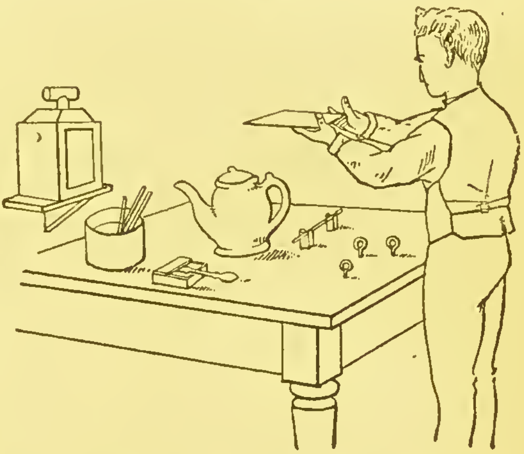
Filtered water	30 oz.
Potash silicate	75 m.

The substratum is applied as follows: After the plates are carefully cleaned, they are placed edgewise in a vessel of water, being completely covered by the same. One plate is lifted out at a time, drained a few seconds, and then has poured over it 2 dr. of the substratum solution, so that the entire surface of the plate will be covered. The plate is again drained a few seconds, and treated to a second flowing of the substratum, is again slightly drained, and then set in and dried in the drying box, Fig. 93, which usually takes an hour.

While the emulsion is filtering into the earthen teapot, all the plates are warmed at one time (and they will retain the heat until coated) in the oven of a stove in the kitchen or over a temporary heater. A marble or slate slab, accurately levelled, is provided, of sufficient size to hold ten 6½ × 8½ plates at a time. The marble top of a washstand answers the purpose well. The floor of the dark room is carefully sprinkled, to avoid floating dust during the coating.

Fig. 89 shows the table and utensils used in coating; upon a bracket is the ruby lantern, just below it is a vessel of hot water, in which are immersed glass rods, in front of this is a small box with a strip of wood over the back for holding the silver spoon level, beside the box is the earthen teapot, next to that are two V shaped wood supports for holding the glass coating rods, and near the end of the table are three screw eyes, rising about an inch above the surface. These are sufficiently separated apart to give a good support to the plate, and must be varied to suit the size of the latter. Fig. 90 shows their relative position. The plate, previously coated with substratum, is now put on

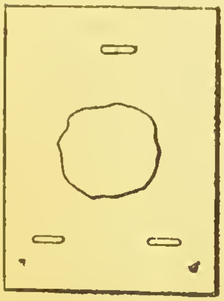
Fig. 89.



the screw eyes and levelled by turning them to the right or left.

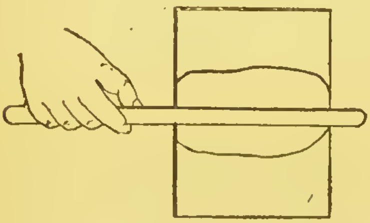
In coating, use two glass rods and a silver spoon, the latter to measure with. Keep these in the vessel of hot water, under the lamp, Fig. 89, when not in use, that they may be clean and warm. Before using, they must be wiped dry with a clean cloth. For coating a 6½ × 8½ plate, use a silver spoon of a size sufficient to hold 4¼ dr. of emulsion; for a 5 × 8 plate, 3 dr.

Fig. 90.



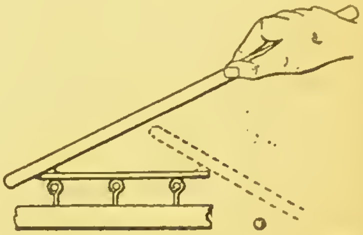
To coat the plate, the stoneware teapot is held in the right hand and the silver spoon in the left; the emulsion is then poured into the spoon until the latter is full, then the teapot is set upon the table. A glass rod about ½ in. diameter is next taken with the right hand, the emulsion in the spoon is then poured upon the centre of the plate in a pool with the left hand (see Fig. 90). The empty spoon is set in the rack box, Fig. 89. With the glass rod placed square across the warm plate, as in Fig. 91, the emulsion is gradually spread out, first by moving the rod to the right, then the left, which carries it to the edge of the plate. Then the rod is slowly drawn toward one end of the plate and then brought back to the centre, thence to the opposite end, passing through that portion of the emulsion not yet spread.

Fig. 91.



In case the emulsion has not been brought quite up to the edges of the plate, it can be made to do so, by raising one end of the rod and drawing it along the edges, as shown in Fig. 92. The emulsion will follow the rod, the latter being drawn along from corner to corner.

Fig 92



By drawing the rod lengthwise to the opposite edge of the plate, and lowering it as shown in the dotted line, the emulsion may be evenly coated along that edge.

In coating, the glass rod should not touch the plate, nor be too high. Only by practice can one judge the proper distance. Bubbles can be removed by placing the end of the rod on them, and they will adhere to it; but one bubble must be removed at a time, and after each removal the rod should be cleaned, or the bubble will be replaced.

Bubbles are caused by having the vessel holding the emulsion too far below the mouth of the filtering funnel; as the emulsion drops, it forms a bubble. No attempt must be made to remove a bubble after the emulsion on the plate has set.

After coating as described, the plate is removed from the screw eye supports and held as level as possible with the hands (see Fig. 89), the thumbs being up, so they will not come in contact with emulsion. The plate is raised to be nearly on a level with the eyes, so that the reflected light from the lantern will strike on top of it. Observe it carefully for bubbles. If these are seen, set the plate back on the screw eyes, and remove the bubbles with the rod, as previously stated. If there are no bubbles, elevate the plate so that the light will strike it on the glass side or below (Fig. 89). The transmitted light shows whether the emulsion is evenly coated. If it appears to be too thin in one portion, the plate is gently tilted, till the emulsion runs over it. When it appears uniform, the plate is put upon the levelled marble slab to set. By the time the tenth plate has been coated, the first will have been found to have set. These are removed and set up edgewise in the drying box. By the time the first six plates have been placed in the drying box, the last lot will be set and ready to remove. All the apparatus is cleaned with hot water after using (the filtering cloth also), and rinsed until the washing water shows no signs of milkiness.

After the tenth plate has been coated, the silver spoon and coating rod are put into the hot water vessel, Fig. 89, which cleans them.

In addition to the guide previously given for the amount of emulsion to be put upon the plate, it is advised that enough be spread to make a wet film so opaque that the flame of a ruby lamp cannot be seen through it. As a general rule, a film is more transparent when wet than when dry.

Fig. 93 is a front elevation of the drying box, with the cover removed. Fig. 94 is a sectional elevation through the line *xx*, showing the cover in position.

Fig. 95 represents a detail view of the drying racks.

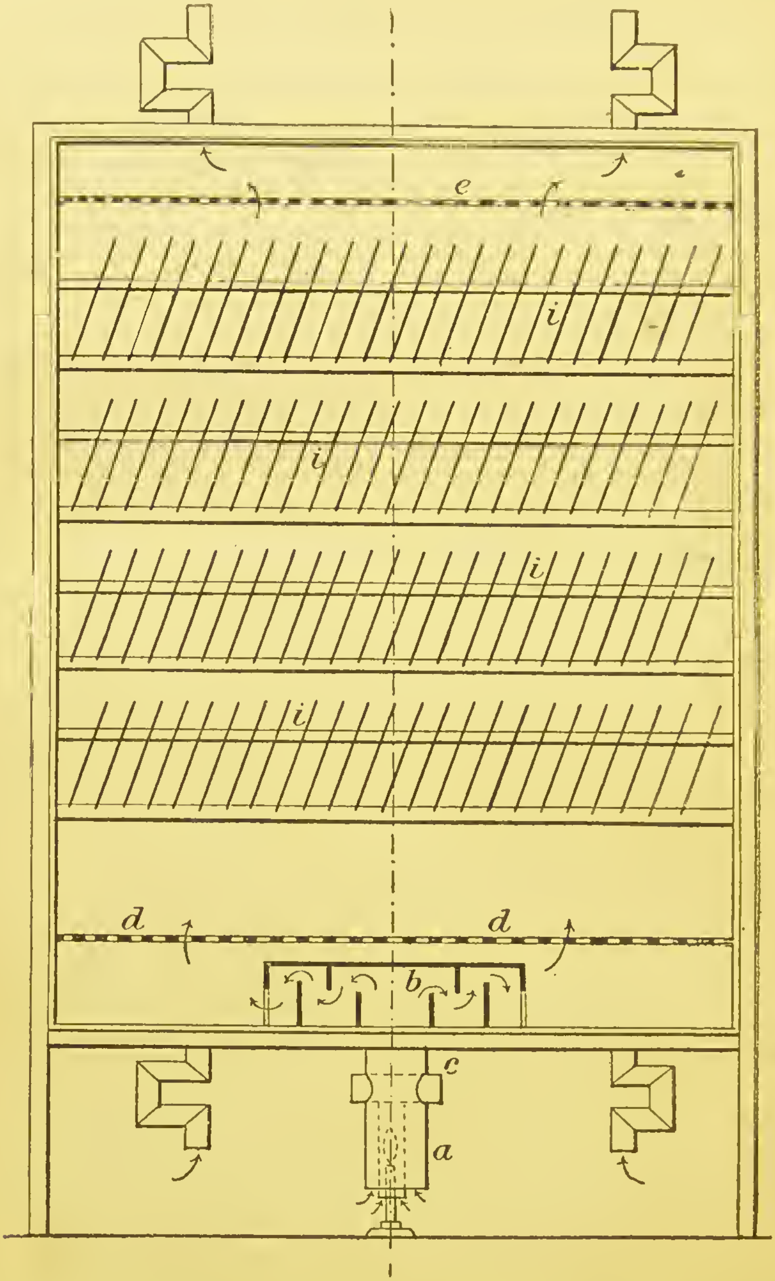
The box may be made either of 1½ in. thick pine boards, or of metal. A size capable of holding 8 dozen plates measures in its interior 37 in. wide, 48 in. high, by 10 in. deep. The box is supported on legs a suitable distance from the floor or table, but, if desired, may also be attached to a side wall. Secured to the bottom of the box is a Russia iron pipe *a* (Figs. 93, 94), 4 in. diameter by 12 in. long. Inclosed within the pipe is an iron gas-pipe *c*, 2 in. diameter, supported therein by a T arm, which projects through each side of the Russia iron pipe, as shown, 3 in. below the bottom of the box. Within the pipe *c* is put the gas or kerosene lamp. The heat from the latter maintains the gas-pipe at a uniform temperature, and escapes through each arm, as indicated by the arrows. By this means no light can enter the box from the lamp. The lamp is burned very low. The temperature of the air entering the box should not exceed 90° F., and the pipe *a* should never get warmer than 110° F. The cool air is drawn in at the bottom of the pipe *a*, between it and the hot pipe *c*, thence ascending to the distributing box *b* (Figs. 93, 94), provided with suitable deflectors, passes out from the box up through the perforated air-filtering partition *d* (consisting of an inch board drilled with ½ in. holes), and is thereby evenly distributed throughout the interior of the box. 8 in. below the top of the box is a second perforated partition *e*, through which the air filters and finally escapes by the two 4 in. diameter bent exit Russia iron pipes as shown. At the bottom of the box are two similar inlet air pipes 3 in. diameter, arranged equidistant between the outer edge and the pipe *a*.

In Fig. 94, *f* represents the door or cover of the box, which is rabbeted to fit over a projecting strip *g*, secured to the inside edge of the box for the purpose of making a light-tight joint. The cover *f*, after being pushed into place, overlaps by 2 in. the outside edges of the box, and is secured thereto by the latch hooks and eyes *h*, at the top and bottom.

When the cover is removed, the entire interior is exposed to view, as shown in Fig. 93.

In place of a removable cover, a vertically sliding door may be arranged, but care should be taken to prevent leakage of light. *i* (Figs. 93, 94, 95) are the coated glass plates as placed when set up to dry. The film side is down. They are supported on notched bar shelves, 1 in. wide by ½ in. thick, the two lower bars (Fig. 95) being separated 5 in. apart, while the upper bar *k* is placed but a short distance above, making it adaptable to hold small and large plates. The plates are set in the notches in the lower bars, and then slide edgewise in the notch in bar *k*. With this box, plates may be thoroughly dried in 20–30 hours. The room must be kept clean and the floor dampened to avoid the danger of dust settling on the damp films. After the plates are dried, they should be removed, dusted with a camel-hair brush, and carefully packed, face to face, or with mats between, in boxes, and the latter kept on edge. When it is desired to remove the cover *f*, Fig. 94, which should not be done until 18 hours after the plates are put in the box, the lamp should be turned out.

Fig. 93.

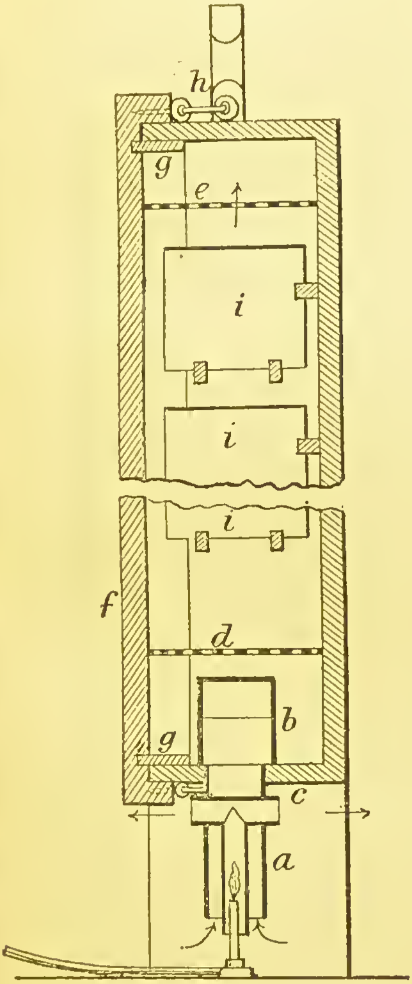


Every article used in making the

emulsion must be carefully cleaned after using.

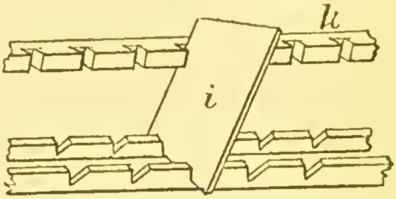
Flasks should be cleaned with shot and tea leaves, as well as the stone bottle. It is difficult to tell when the stone bottle is perfectly clean, hence extraordinary precautions are required. It should first be rinsed out with boiling water, and then treated with shot and tea leaves, and again well rinsed.

Fig 94.



The rapidity of the emulsion is estimated to be equal to 20 on Wernerke's sensitometer. The ferrous oxalate developer will work well with these plates, also the potash carbonate and pyro developer. The former is prepared by making saturated solutions in boiling water of iron sulphate and neutral potash oxalate. Both solutions, when cool, may be acidified with sulphuric acid. The iron solution needs but 3 drops of acid to 32 oz. of solution. The oxalate is acidified until blue litmus paper turns red.

Fig. 95.



The normal developer will then consist of:

Saturated solution potash oxalate	3 oz.
Saturated solution iron sulphate	½ oz.

In case of under-exposure and slow development, the iron solution can be safely added to the oxalate, which should always be the order of mixing, until the proportions do not exceed 1 oz. of iron to 3 oz. of oxalate. To remedy over-exposure, the developer should consist of 1 dr. of iron to 3 oz. of oxalate, with one or two drops of the following solution added:

Water	1 oz.
Potassium bromide	48 gr.

Should the development proceed too rapidly, more bromide should be added, 2 or 3 drops at a time. On the other hand, if it is too slow, more of the iron solution should be added, in small quantities at a time, until the desired speed is reached. This developer is particularly recommended for landscapes. For general and drop-shutter work the pyro developer known as "the Beach potash developer," gives excellent results, and allows considerable latitude in exposure. It is prepared as follows:

No. 1.—Pyro Solution.

Warm distilled or melted ice water..	4 oz.
Chemically pure soda sulphite..	4 oz.

When cooled to a temperature of 70° F., add:

Sulphurous acid	3½ oz.
Resublimed pyrogallol ..	1 oz.

The pyro is best dissolved by pouring the sulphite solution into the pyro bottle, and then out into a graduate, repeating the pouring until completely dissolved.

If pure, it will dissolve very rapidly. When completed, the solution should measure 9½ fl. oz.

No. 2.—Potash solution is prepared with two separate solutions as follows, each ounce of the salt containing 437 gr.:

a	Water	4 oz.
	Chemically pure potash carbonate	3 oz.
b	Warm water	3 oz.
	Chemically pure soda sulphite	2 oz.

a and *b* are now combined, forming one concentrated solution.

Each ounce of No. 1 contains approximately 48 gr. of pyro, and each ounce of No. 2, 154 gr. of potash.

It will be seen that the potash solution is quite concentrated, so that a small quantity is only necessary for use in development.

A normal developer would be made up as follows:

Water..	2 oz.
Pyro solution (No. 1) ..	1 dr.
Potash solution (No. 2) ..	30 m.

If more density is required, 1–2 dr. more of No. 1 may be added. If the development proceeds too slowly, 1–1½ dr. of the potash solution may be added in small quantities at a time, until the right speed of development is attained.

By thus varying the proportions, the developer can be made to suit either an over or an under exposed plate.

The negatives possess a brilliant, clear, bluish-gray colour. (H. London.) (See also iv., 344.)

Colour-sensitive Collodion Emulsion.—Albert's collodion emulsion contains the same modification of silver bromide as the ordinary well known collodion emulsion—that is to say, a white silver bromide, sensitive to the violet and indigo rays of the spectrum.

Experiments have shown that there is no difference between Albert's emulsion in the undyed state and the collodion emulsion as hitherto well known. The novelty lies only in the colour-sensitiser. With regard to the latter, it has been already stated that it contains erythrosin, but that silver could not be recognised therein by the accustomed test of hydrochloric acid. Close examination of the matter shows that eosin silver dissolved in dilute nitric acid only gives a precipitate with hydrochloric acid when there is a little silver nitrate in excess: otherwise not.

Further trials with Albert's portrait dye solution gave results unmistakably like those obtained with a solution of eosin silver in ammonia. Both solutions showed, when carefully neutralised with nitric acid, a cloudiness, and precipitation of red erythrosin silver. Albert's colour solution, however, proved to be in a more concentrated state than a saturated solution (about 1 to 1000) of erythrosin in alcohol.

From various trials it was found that erythrosin is much more soluble in methyl alcohol than in ethyl alcohol, and that a solution of 1 part of erythrosin in 200 parts of methyl alcohol was more intense in colour than Albert's solution. This solution (of erythrosin in methyl alcohol) was then added in the proportion of 1 in 10 to the collodion emulsion, and tried. The colour-sensitiveness proved, however, to be but slight, and did not approach that of Albert's preparation.

The dye solution was now mixed with an alcoholic solution of silver, and the precipitate was redissolved in alcoholic ammonia. The solution thus obtained was added to 10 times its amount of bromo-silver collodion emulsion. Thus was obtained an emulsion which corresponded completely with Albert's portrait dye collodion, both in colour-sensitiveness and in general sensitiveness. Addition of picric acid made not the slightest difference to it.

There remains no doubt that Albert's colour-sensitive collodion emulsion (for portraits) consists for the one part of a collodion emulsion prepared in the customary way and for the other part of a very concentrated solution of erythrosin silver in methyl alcohol and ammonia, with some picric acid. The value of the picric acid remains undecided. To Dr. Albert, however, is due the credit of having first discovered the surprising sensitising power of a very concentrated solution of eosin silver in ammonia. Without his example others would not so quickly have come upon the interesting fact that it is possible to prepare colour-sensitive collodion emulsion attaining the sensitiveness of gelatine emulsion. Dr. Albert has thereby opened a new road.

Formula for an erythrosin silver dye solution:

A.—Erythrosin	0·5 grm.
Pure methyl alcohol	100 cc.
B.—Silver nitrate ..	4 grm.
Warm water ..	4 cc.

After solution, add 96 cc. pure alcohol at 96°.

10 cc. of A is mixed with 1 cc. of B and 4 cc. of alcohol (not aqueous) ammonia. This mixture will keep.

For use, 1 part of the solution is shaken up with 10 of bromide-silver collodion emulsion.

As a developer, employ hydroquinone with soda carbonate and a few drops of solution of ammonia bromide, according to the following formula:

1.—Hydroquinone	10 grm.
Soda sulphite	50 grm.
Water	700 cc.
2.—Crystallised soda carbonate	100 grm.
Water	800 cc.

60 cc. No. 1 are mixed with 10 cc. of No. 2, and 2 or 3 drops of a 10 per cent. solution of ammonia bromide are added thereto.

The only drawback to the process is that the plates are only useful in the wet condition. When dry, they are 20 times less sensitive; and as dry plates, generally useless.—(H. V. Vogel.)

Platinotype.—Probably all photographers are sufficiently familiar with this process to know that in printing the platinotype paper the image which appears is not brown or purple, but of a faint greyish-yellow colour, and therefore it is rather difficult to judge whether a print has had sufficient exposure in the frame, as may be done in the case of albumenised paper.

To remove this drawback, which to some degree has been prejudicial to the popularity of this printing process, Capt. Pizzighelli, to whom we are indebted for much valuable information on the subject of platinum printing, has made many experiments, but only recently has he succeeded in finding out a method of producing platinotypes directly in the printing frame without development.

The principles of this method are the following:

1. If to the sensitising solution certain vehicular substances are added, this solution will be prevented from penetrating into the body of the paper.
2. If to the sensitising solution one of those substances which serve as developers is added in the very beginning, a reduction of the platinum salt takes place directly in the printing frame by atmospheric influences.

The advantages of the new process are, therefore, very important, as there is no longer a necessity for a preliminary preparation of the paper, and as you can judge of the exposure as accurately as with silver. Besides this, the development of the paper is entirely omitted. A simple, short washing of the prints, first in acidulated, then in ordinary water, is sufficient for finishing the pictures.

Sensitising the Paper.—For coating, Rives or Saxe paper may be used, either glossy or with a matt surface.

Solutions of gum arabic and of arrowroot have been found the best vehicular substances for the sensitising liquid, but the former has proved to give better results than the latter. They are mixed in the following manner:

I.—	Gum arabic	50 grm.
	Distilled water	100 cc.
II.—	Arrowroot	2 grm.
	Distilled water	130 cc.

The latter is boiled in the usual manner to paste. Before use mix:

Sensitising liquid	2 parts
Gum solution I.	1 part

Or,

Sensitising liquid	1 part
Arrowroot paste II.	1 part

The mixture is well stirred until it forms an entirely homogeneous liquid, and then it is filtered through muslin.

The coating and drying of the paper, and its storing in tin cylinder boxes, in which dry calcium chloride is placed, is the same as in the case of the old platinotype process.

The sensitising solution is prepared as follows: To the normal ferric oxalate solution is added in the dark room, and keeping the dish rocking, as much of neutral ammonium or sodium oxalate as will just dissolve at the ordinary temperature. For this purpose will be required of the above named salts:

To normal ferric oxalate solution	100 cc.
Neutral ammonium oxalate	18 to 20 grm.
Or to normal ferric oxalate solution	100 cc.
Neutral sodium oxalate	15 to 18 grm.

By formation of the corresponding double salt the brownish-grey colour of the ferric oxalate changes to a beautiful emerald green. If the solution begins slightly to darken, this will indicate that the saturation is completed. As soon as this takes place, no more ammonium or sodium oxalate should be added. Keep the dish rocking for some further time, allow to set, and then filter.

The solution may be mixed as follows:

Potassium chloro-platinite solution (1 part to 6 parts of water)	24 cc.
Ammonia ferric oxalate solution, or sodium ferric oxalate solution	22 cc.
Gum solution I.	23 cc.

If ammonium oxalate be added, the prints will be of a more bluish tone; while, by the addition of sodium oxalate, they are rendered more brownish. The former gives somewhat softer prints than the latter. As to the sensitiveness, there has been found no marked difference between the two salts.

Potash chlorate may be added with the effect of increasing contrast, and this may be done in the same manner as with the old platinotype process.

The above given quantity of the sensitising liquid is sufficient for five sheets of the ordinary size. The exposure of the paper no longer offers any difficulty. As the results will be more satisfactory if the paper possesses a certain degree of surface moisture (as in the case of silver printing), it will be well to take the sheets to be worked, a few hours before use, off the tin cylinder, and to hang them up in the dark room. In placing the paper on the negative, it is, with this process, of course, not necessary to place behind it a sheet of vulcanised rubber sheeting or a piece of waxed paper.

In printing and finishing the picture, the following modifications are allowable:

1. The printing is carried on until the image has appeared in all its parts. The picture when taken out of the frame should not be darker than it should be when finished.

2. The printing is only continued until the picture is in general visible, but the delicate half tones are still wanting. The picture is taken out of the frame and kept separately. In about ½–2 hours the picture will be finished by itself, as the reduction of the platinous chloride, once introduced, is continuous in the dark; or the picture is developed out with a cold diluted solution of sodium carbonate.

A good solvent is the following:—

Saturated solution of soda carbonate	5 cc.
Distilled water	100 cc.

In this solution the picture is immersed and allowed to remain until all the delicate details are to be seen, which will require only a few seconds.

3. Printing is continued about as far as with the ordinary platinotype paper, i.e. until only those parts of the negative which are clear glass, or nearly so, are distinctly visible. Then development is carried on as with the ordinary platinotype paper.

The pictures printed according to one of the methods 1, 2, or 3, are placed in

Hydrochloric acid	1 cc.
Water	80 cc.

and allowed to remain there until the yellow colour of the ground of the paper has disappeared. Then they are, for 10–15 minutes, washed in 2 or 3 changes of water.

For the preparation of the solution of ferric oxalate the following operations are necessary:

1. Manufacturing the ferric hydrate.
2. Dissolving that substance in oxalic acid.
3. Determining the amount of iron and of oxalic acid contained in this solution.
4. Diluting and acidulating the same.

The method of preparing ferric hydrate is generally well known, but for the sake of completeness we will give a brief description of it. Ferric chloride, 500 grm., is dissolved in 5-6 litres of water, and when the solution has been brought to the boiling point, solution of soda is added, until it gives with litmus paper a distinctly alkaline reaction. For this purpose about 250 grm. of caustic soda will be found necessary. The precipitate is then washed with hot water by decantation, until the wash water is no longer alkaline. It is next placed in a cloth, and by pressure freed from the greater part of the water. With the ferric hydrate thus obtained, which ought to have a sirupy consistency there should be mixed about 200 grm. of finely crystallised oxalic acid, and the mixture be then left to itself for a few days at a temperature of not more than 85° F., and in a place completely protected from the light. Under these circumstances the formation of ferric oxalate will go on steadily.

Some recommend the promotion of this process by digesting the mixture for some time at a high temperature. This we are decidedly opposed to, since by heating for even a very few hours to 110°–140° F., the salt will be partially reduced to a ferrous oxalate. At the commencement the solution has a pure green colour, by continued digestion it turns yellowish-green, and finally greenish-brown. When this moment has arrived, the remaining ferric hydrate should be filtered off, and the solution be submitted to a quantitative chemical analysis.

Although the determination of the amount of iron and oxalic acid contained in the solution is one of the simplest of analytical operations, we tried at first to dispense with it. Closer investigation, however, proved how necessary it is to confine the relations between rather narrow limits, in order to ensure the success of the platino-ferric process. Now as ferric oxalate cannot be prepared in a stable form, so as to have a constant composition, there remains no other way than that of determining the composition of the solution by analysis, and then diluting it to the required degree. Further, it should be noted that any quantity of the solution may be prepared at once, and then kept in stock.

From the analysis we ascertain the quantity of ferric oxalate contained in 100 cc. of the solution, as well as any slight excess of oxalic acid which happens to be present. The liquid is then diluted with so much distilled water that every 100 cc. of it may contain 20 grm. of ferric oxalate [$Fe_2(C_2O_4)_3$]. Crystallised oxalic acid is then added until, with the free acid already in the mixture, that substance amounts to 6–8 per cent. of the ferric oxalate already in the solution—the normal ferric solution.—(H. C. Gunther.)

Platino-Uranotype & Mercuro-Uranotype.—First, make a saturated solution of neutral potash oxalate, and dissolve dry ferrous oxalate in this to saturation.

The process is very simple, for the operations involved are merely:

1. Coating the paper.
2. Exposing same in printing frame.
3. Development (which takes only 5–10 seconds).
4. Fixing in HCl ($1\frac{1}{2}$ p. cent. solution).
5. Rinsing in water, drying, and mounting.

In recent experiments, uranium chloride has replaced the nitrate in the sensitising solution, and better results are to be obtained from its use. As in Willis's processes, potash chlorate may be added in minute quantities to the sensitising solution to increase contrasts.

The following seem good proportions for the sensitising solutions:—

A.

Saturated solution of uranium chloride.

B.

Potassic platinous chloride ..	60 gr.
Water, distilled	$1\frac{1}{2}$ oz.

90 minims each of A and B are spread over a well-sized sheet of paper, 26 × 20 in.

Now for the most perfect form of platinotype (by any process) to be obtained, it is not difficult to see that the platinum should not form a part of the sensitising solution, but should be deposited on an image already formed by an action similar to that of toning silver prints with gold, and for this reason no platinum in the "paper" or "printing-out" process can ever give the detail of a silver print. The mercuro-urano-type process may turn out to be useful for rapid proofing of negatives, if for nothing else, for the tone is not very objectionable, and if preferred may be modified. Paper is coated with one or the other uranium solution, to which has been added some saturated solution of mercury bichloride (say 1 part mercury solution for every ·8 of the uranium solution). A sheet of paper is coated with about 170 m. of this solution, and dried in the dark. It is then printed behind a negative until it attains full strength, which will take only a few minutes; it may then be floated on solutions of gold or platinum to obtain a more pleasing tone, and next placed in water acidulated with HCl, or the toning omitted and the print treated as if it were Pizzighelli paper. Thus it will be seen that this process is one of the simplest known.

If more attention were directed to the salts of uranium many latent and valuable properties would in all probability be discovered; their reactions are very powerful, and should be more generally known than they are at present.—(A. Reynolds.)

Views and Landscapes.—In taking views, the process is exactly the same as in the case of portraits, except that the exposure is very much less. Views can be taken with the ordinary portrait lens, although distant objects are generally produced by it on too small a scale; this difficulty may be overcome by removing the back pair of lenses from the tube and using the front combination only, provided the camera will open to a sufficient length for focusing.

Photographic News-letters.—To procure these minute photographs, an ordinary negative must be taken, great care being necessary to obtain a negative that is perfectly clear at the edges, as well as in the centre. This operation will produce a photograph as much smaller than the original as the power of the lens and length of focus will allow. From a print taken off the negative thus obtained, another negative still more reduced must be taken, and this operation repeated if necessary until the final photograph is obtained of the desired size. The last positive must be printed on very fine transparent paper, and all the usual operations for toning and fixing carefully performed. On arriving at its destination, the letter must be carefully unrolled and mounted on glass, then by the aid of a gas microscope attached to a powerful phantasmagoria lantern the image can be reflected on to a screen, and will be so much magnified as to be easily read and transcribed. If rapidity of copying is desired, the image on the screen may be divided into portions by lines, and several persons set to copy at the same time.

Nature Printing.—There are two methods employed for obtaining facsimiles of ferns, leaves, sea-weeds, one suited to the amateur, the other for commercial purposes.

(*a*) For the former the requisites are small quantities of coloured printing inks, black may be used, but the natural colours look much better, a little cotton wool, and some pieces of very soft wash-leather. Either fresh or dried leaves may be used; the former require no preparation, the latter should be dipped in water, and then left between damp blotting paper for some time to become tough, or they sometimes crumble to pieces during the manipulation. A dabber about the size of a marble is made of cotton and soft leather tied up, a small quantity of ink of the desired colour is put on a piece of glass, and the dabber is covered with it, using as little as possible. The side of the leaf from which the impression is to be taken is then laid, face upwards, on a piece of clean paper, and the dabber is employed lightly to coat all the prominent parts of the leaf with the ink. The leaf is then laid, ink side downwards, on a piece of moistened paper, covered with another similar piece, which may be kept in place by lead weights if necessary. The part under which the leaf remains should then be carefully pressed with a dabber, similar to that used for the ink, taking care to go steadily and evenly over the whole surface of the leaf. Of course it is necessary to take great care to prevent the leaf or paper from shifting. Any number of impressions may be taken from one leaf. Inks may be mixed with a small palette knife to obtain any shade of colour, and two or more colours may be used on one specimen.

(*b*) In the commercial process, the leaf, or other object, is placed on a steel plate, and covered with a leaden plate scraped bright; it is then subjected to great pressure, which leaves a beautiful impression on the lead. From this a copper matrix is taken by the electrotype, which in turn serves to produce an intaglio plate in copper, from which impressions may be taken in the usual manner.

(*c*) A piece of writing paper is moistened with olive oil and thoroughly smoked over the flame of a tallow candle, the leaf, which should be dry, is laid upon it, covered with a piece of paper, and well dabbed all over, then transferred to a piece of clean paper, and the dabbing is repeated, when it will leave an impression much like a very delicate pencil drawing.

Photography on Silk.—(*a*) Pour 20 oz. boiling water on 100 gr. ammonium chloride and 60 gr. Iceland moss. When nearly cold, filter, and immerse the silk in it for 15 minutes. To sensitise, immerse the silk in a 20-gr. solution of silver nitrate for 16 minutes. Let the nitrate bath be rather acid. When dry, prepare for printing by attaching the silk to a piece of cardboard a little smaller than itself, by turning the edges over and fastening with small pieces of gummed paper. Slightly over-print. Wash in 2 or 3 changes of water, and tone in a gold bath made thus—29 oz. water, 2 dr. soda acetate, 4 gr. gold chloride, and a few gr. common whiting. Filter and keep for 24 hours before using. Let the prints be toned slightly bluer than they are required to be when finished. Rinse them in water, and fix in a solution of hypo., 4 oz. to the pint of water; 20 minutes is ample time for fixing. Wash well.

(*b*) Dissolve by soaking for about 6 hours, and afterwards gently heating, 10 gr. fine white gelatine in 20 oz. water, and when solution is complete add 45 gr. ammonium chloride; filter and label No. 1. Make No. 2 solution of silver nitrate 300 gr., citric acid 3 gr., water 10 oz., filtering as usual. To sensitise the silk, cover it first with

No. 1 solution, and after that has dried, with No. 2. A sufficient quantity of No. 1 to completely coat the silk having been poured on, it is spread over the entire surface by means of a canton flannel swab, and is allowed to remain on the silk about two minutes, after which the surplus is removed and the frame is set aside to dry in a place free from dust. The No. 2 solution is then applied in the same manner for about 2 minutes, except that the operation must be performed in a dark or dimly-lighted room. Before printing, the silk is drawn tight over a stretcher, care being taken to remove all wrinkles and to secure a perfectly flat surface. The negative is then placed in the printing frame, and upon it the silk stretcher. The printing, toning, and fixing are accomplished in the ordinary way, except that the print is a little darker than on silvered paper, and toned to a somewhat colder colour.

(*c*) Make the following solutions:—

No. 1.

Tannin	40 grm.
Water	1000 cc.

No. 2.

Salt	40 grm.
Arrowroot	40 grm.
Acetic acid	150 cc.
Water	1000 cc.

No. 1 is mixed with No. 2, well shaken, and filtered. The older the mixture, the better it is for use. In this bath the silk is thoroughly immersed, and allowed to remain for 3 minutes, when it is taken out and hung up to dry.

Sensitising solution is composed of silver 1 to 10 grm., acidified with nitric acid.

Toning Bath.

No. 1.

Gold chloride	1 grm.
Water	200 cc.

No. 2.

Ammonium sulphocyanide	20 grm.
Water	500 cc.

No. 1, after shaking, is mixed with No. 2. In a few days the mixture will become clear, when it is ready for use. It is preferable to dilute with 2–4 times the quantity of water. Fixing and washing as usual.

Autotype or Carbon Printing.—Johnson's process is adapted to supply the place of albumenised paper and silver, gold, and hypo. solutions; the manipulations are more simple than silver printing, and less skill is required for producing prints by this method than by the usual silver one. The most troublesome portion of any carbon process is the preparation of the tissue, that is, the sheet consisting of the layer of gelatine and carbon or pigment. This carbon tissue consists of a layer of gelatine containing the carbon or other permanent pigment spread on paper. As sold it is not sensitive to light, but requires the action of a solution of potash bichromate to render it sensitive. So far the process resembles the silver printing one—the tissue corresponding with albumenised paper, the bichromate sensitising solution with the silver one. When the paper is dry, the coloured surface is placed in contact with the negative, and exposed to light; the exposure should be about one-third the time required for silver printing. The pigmented paper is prepared in long rolls, so that much larger sheets can be obtained than of albumenised paper. It should be cut into convenient sized sheets for sensitising. A solution, 20 gr. to the oz. of potash bichromate is provided in a flat dish. The sheets may be placed in the solution one at a time until all are immersed. Each should be turned over to see that no air-bubbles form. They must remain in for one minute, but may stay longer without injury. They should then be taken out, and hung to dry. This sensitising and drying must be done in chemical darkness, like sensitising silvered paper; more caution must, however, be taken, as the carbon paper is so much more sensitive. When the paper is dry, it must be placed in contact with the negative to be printed. It is advisable for carbon printers to classify their negatives. Let those negatives that print the quickest be called No. 1; those that require longer printing, No. 2; and those still denser, No. 3. By the use of an actinometer, the amount of printing given in a certain time can be measured. This simple little apparatus consists of a round japanned tin box, with a slot in the lid about ¼ in. wide and 1 in. long, like a money-box. Inside the box is a strip of Carrier's sensitised albumenised paper, about ½ in. wide, coiled up in a roll. The lid of the box is painted a chocolate colour, like the tint that sensitised albumenised paper quickly takes when exposed to the light. By simple means, a portion of this paper is pulled out of the box, and in doing so a portion is exposed to light through the slot in the lid, the rest of the strip being screened from light. The paper when exposed begins to darken, and presently arrives at the same tint as that surrounding it on the lid of the box. Let us suppose a negative to have sensitised pigmented paper placed under it, and the actinometer to have a piece of the white sensitive silver exposed through the slot, then let the actinometer and the negative be both exposed simultaneously to the same light; by the time the light has darkened the silver paper to the standard tint, the actinometer and the negative will both be said to have received one tint, that is, they will both have received that amount of action from the light necessary to produce on the silvered paper that particular tint. In the first instance each negative, or each class of negative, will have to be tested by the actinometer, how many tints have to be darkened before the carbon print is made, and the negatives may then be marked accordingly. When a negative has been once tried and marked the number of tints it requires, no mistakes will be made afterwards as to the exposure that will be required. The next operation is to attach the print to a temporary support during the development, or removal of the unacted-on pigmented gelatine. Plain gelatine is not sensitive to light, but is easily soluble in hot water. The potash bichromate makes it sensitive to light, and the change effected in the gelatine by light renders it insoluble in hot water, but the rest of the gelatine still remains soluble. The insoluble portion constitutes the picture, and it is necessary to dissolve everything but that which light has rendered insoluble. The print has to be attached for this purpose to a temporary support. Almost any substance impermeable by water will answer, but some substances are more convenient than others, such as the surface of ground opal glass, or zinc plates that have a finely-ground surface. To facilitate the removal of the print from this slightly-roughened surface, rub the support over with a dilute solution of rosin and wax in turpentine, using a soft rag, and leaving only a very thin film of the solution on the surface. The pigment print is first immersed in cold water, gelatine side downwards; the print at first curls inwards as the paper on the back expands with the water, but in a few seconds it flattens and shows signs of curling outwards; at this juncture take it out, and previously wetting the glass or zinc that you are going to develop it on, lay it on gelatine side downwards, and with a rubber scraper, or squeegee, press the print in close contact to the support to expel the water. Sweep the squeegee backwards and forwards once or twice to get rid of all moisture that can be driven out. Allow the print to remain thus for a few minutes, and if you have other prints ready to go on with, you may serve them all the same until you have several ready. This pressure ensures the perfect adhesion of the print to the surface of the support through all the subsequent hot and cold water washings. The glass or zinc with the print thus firmly attached by atmospheric pressure may now be immersed in hot water at say 100° F. Let it remain for a few minutes. When the coloured gelatine begins to show itself oozing from the edge of the paper, try one of the corners of the paper if it will lift easily; if so, lift it slowly and steadily from the support, and it will come off, bringing with it a great deal of the unaltered gelatine. If it does not lift off easily, allow it to remain until it will do so. On no account force it up. The time it takes for the paper to come freely away depends on the temperature of the water it is immersed in; the water need not be hotter than the hands can bear. When the paper is removed the rest of the unaltered gelatine will speedily flow away, and the picture will gradually emerge from the dirty mass that envelops it. Allow it to remain in the hot water till all the soluble gelatine is removed; this is known by the ceasing of the dirty or coloured streams that previously have come from the picture. There is no fear of the print itself being dissolved away, for the altered gelatine that forms it is insoluble. When all that will come away has come away, remove the glass from the warm water, and well wash in cold water; the picture may then be set aside to dry, still adhering to the glass or zinc. When the print is in this state it can easily be seen if the exposure to light under the negative has been too little or too much. If it has been too little, the print will be too light, that is, there will not be enough pigmented gelatine left on the glass to properly represent the negative, showing that sufficient time was not given for the light to render enough of the gelatine insoluble. The print will betray the deficiency of exposure by the absence of the half tones. If the print is too dark, then the exposure has been too great, and too much of the gelatine has been rendered insoluble. If either error has been committed a mark should be made on the margin of the negative showing the greater or lesser number of tints that the negative should receive in future printings. Gelatine prints never look sharp when they are wet; they will be sharp enough when the gelatine is hard and dry. After the print is dry, proceed to transfer it to the permanent paper base on which it is to remain. Ordinary plain paper, or even paper slightly gelatinised, is not sufficient for finally attaching to the image on the glass or zinc. If such papers be attached to the gelatine image, the finer parts of the high lights and half-tones are so attenuated that this kind of paper will be sure to leave them behind. There is, however, a paper provided with a coating of insoluble gelatine that readily attaches itself to the image, and brings it all off the glass.

Colouring Carbon Prints.—Carbon photographs admit of colouring in oil, water, or powder colours, without risk of damage; the manipulation is easier than that upon albumenised silver prints. Powder colours adhere very readily to the surface of these prints. By breathing on the picture a still more adherent surface is obtained.

Water Colours.—The water colours take kindly without any preparation, washing well, and permitting tint to be worked over tint without difficulty, and the surface may be made more pleasant for working on by the application of a coating of sizing preparation. The plain carbon print so treated acquires an even, clear surface, losing all gloss without any loss of depth or transparency.

Oil Colours.—The best mode of preparing a carbon print for the reception of oil colours is by sizing it with isinglass. A solution of about 2 per cent. of isinglass in equal parts of hot water and spirits of wine, carefully applied, not too hot, to the surface of the carbon print, with a flat camel-hair brush, yields a surface upon which oil colours work admirably.

Re-touching Carbon Prints.—In the ordinary process of re-touching carbon prints, to remove small imperfections, it is only necessary to use the proper colour in the usual way; if a little gelatine, with a trace of a chromic salt, is employed with the colour, it will, when dry, become insoluble like the rest of the picture. If the re-touching is effected with the same materials before transferring the print, it will, when the picture is finished, be under the image, and no inequality of surface, usually apparent after touching, will be seen.

Photo-micrographs, or Photographs for Microscopic Slides.—The lens being removed from an ordinary ¼-plate camera, a mahogany cone, blackened inside, and about 2 in. deep, is substituted, made to fit tightly into the flange of the camera, and having an opening at the apex through which the tube of the microscope can just pass freely, and only just, and to which a rubber band very slightly smaller than the tube of the microscope should be glued, to prevent light entering between the microscope and the cone. The microscope is then placed in a horizontal position, and the eye-piece having been taken out, the tube is passed through the cone and the eye-piece is replaced. The object to be photographed, which should be as transparent as possible, is then secured on the stage of the microscope, the manner of doing which, when the stage is vertical, varies with the construction of the microscope. This may be done with two small slips of wood 3½ in. by ¼ in. under the stage, one on each side of the opening, and two small rubber bands slipped over the ends of both wood and slide. The object can then be focused on the ground-glass screen, but as the microscope is not specially constructed for the purpose, the chemical and visual foci do not coincide, and the chemical focus must be found by experiment. A few trials, using the fine adjustment, will give the requisite difference between the two foci, which, once found, is constant. A strong light must be employed, but not direct sunlight. The light from a white cloud on a bright day is the best illuminator. No special collodion or developer need be used, beyond being of the best, a necessary point in every photographic operation. The exposure will, of course, vary with the intensity of the light, quality of the lenses of the microscope, sensitiveness of the plate, &c. It should, however, be short, as the image is very bright with a good microscope. If there are many to do, it will be found advantageous to contrive an arrangement of both microscope and camera on a board which can be screwed to the camera stand. Some operators prefer to work without the eye-piece of the microscope, but there is then sometimes an objectionable flare in the centre of the picture. The eye-piece occasions some little loss of light, and therefore it would be preferable to work without it if possible.

Photo-Micrographs on Gelatine Plates.—For the negative, a plate of extreme sensitiveness and fine texture, developing with sharp contrasts and great density, is required, and development with pyrogallic acid has given better results than ferrous oxalate. With such plates, powers ranging from 4 diameters to 2000 may be successfully employed with the light obtainable from a good lamp, while a simple and inexpensive camera, and which can be adapted to any microscope, is all sufficient for the production of the most perfect negatives by any process between the above extremes.

The gelatine plates for making the positives are of quite a different character from those used for negatives, being much less sensitive to light, and requiring a development which shall produce clear glass in the high lights, transparency in the shadows, and full detail in all portions. Two distinct kinds are now made, the one with a silver bromide base, the other with a chloride. The latter is much slower than the former, requiring many times the length of exposure, but the transparency of the shadows is much greater.

Possessed of a good negative (no other should be used, since it is not possible to make a good positive from a bad one), two methods of producing the latter are open to us—by contact printing or by the camera. The latter is undoubtedly the more perfect, and enables us to utilise a negative of any dimensions, enlarging or reducing it to the proper lantern slide. A deep printing frame with plate glass front must be employed, on which is laid the negative, film side up; upon which—film side down, so that the two shall be in contact—is placed the slow plate which is to form the positive. Of course this must be done in the dark room, by ruby light. A piece of dead black velvet, to prevent halation or any reflection from the back of the plate, must now be placed over the same, and the back of the printing frame secured in position. The exposure is made to the light of a lamp or gas jet, at a distance of about 15 in. If a bromide plate be employed, the length of exposure may vary from 5 to 20 seconds, according to density of the negative: if a chloride plate, however, be used, the time required may be as many minutes. No rule can be given, experience alone will enable one to determine with any certainty the length of time required. For negative making, the "diamond" plates by Richardson are eminently satisfactory, while Carbutt's transparency plates, both bromide and chloride, leave little or nothing to be desired. They are cut from extremely thin and flat glass, so that when covered with a slip of the same thickness, and the edges neatly bound with needle paper, they present an exceedingly attractive appearance, and are very light in weight, fitting readily the cavities of any lantern in common use.

The development of the plate is of the utmost importance, since upon its success depend the beauty and perfection of the resulting transparency. The image should be sharp, clear, and transparent in the deepest shadows. Where clear glass appears, it must be absolutely so; the least smokiness or muddiness will spoil the brilliancy of the image upon the screen. The ferrous oxalate, made in the following simple manner, is entirely satisfactory when used with the Carbutt plates:—

No. 1. Saturated solution neutral potash oxalate.

No. 2. Saturated solution iron protosulphate. To the latter add a few drops of a saturated solution of citric acid.

To make the developer, add 1 part of No. 2 to 6 of No. 1, and have ready a solution of ammonium bromide for use in case of over-exposure. This developer will be found to act very promptly, and to bring out all the details with proper density before those portions of the plate which have not been acted upon by light, and which should be clear glass, begin to show any signs of fog. If the plate we are using be one of the bromides, it will be well to continue the development until rather more density than is desired has been obtained, as it will lose somewhat in the subsequent fixing. If, on the contrary, we are using a chloride plate, the development must be stopped as soon as requisite density is reached, as it will lose nothing in fixing. The usual washing and fixing in the hypo bath, followed by an alum one, and prolonged washing to remove all traces of the soda hyposulphite, must follow as a matter of course. Should the image flash up too suddenly, from over-exposure, add a few drops of the bromide solution to prevent flatness and want of contrast in the image.

If the negative image be of larger dimensions than the lantern plate, and it be desired to place the whole thereof upon the latter, it will be necessary to employ some kind of copying camera. One especially constituted for this purpose, with a double shifting front, capable of carrying one sized plate, will of course be found the best. In the absence of such, we may successfully use the same camera with which the negative was made, by removing the cone front and putting the negative in its place; which can readily be done by any one possessing a little patience and ingenuity. Then a board carrying a rectilinear lens of moderate focal length must be inserted in the central division of the bellows, and the front elevated toward the sky. An image of the exact size required may now be thrown upon the forming screen by withdrawing the front section of the bellows, carrying the lens to the proper distance, when it must be clamped, and the forming effected by the back bellows which carry ground glass screen. The plate holder containing one of the slow lantern plates is now to be substituted for the ground glass, and an exposure of 5–20 seconds made, governed by the density of the negative. The subsequent operations of development and fixing are precisely the same as those given for contact printing.

Should the resultant positive be lacking in density, or of a slaty hue and without crispness, it may frequently be greatly improved by the following method:—

After thorough washing to remove all traces of hypo, place it in a bath composed of

Mercury bichloride ..	96 gr.
Potassium bromide ..	90 ,,
Distilled water	12 oz.

This bath, it may be observed, should be returned to a well-stoppered bottle for future use, as it will retain its qualities for a very long period.

Its effect upon the gelatine film of the plate will be to bleach the same, but care must be exercised not to carry the bleaching too far, lest over density be the final result. Removed from this bath and well washed, it must be plunged into another consisting of a 12 per cent. solution of soda sulphate, until the desired tone is reached. Almost any gradation of colour from a light yellow-brown to black, may be thus obtained, varied by the length of time immersion in the soda bath is continued. Final washing and drying must follow as in the original development.

When dry, the film is to be protected from injury by covering it with a thin plate of glass of the same dimensions as the slide, with a mat of paper cut out in suitable shape placed between the two, and the edges bound around with a strip of needle paper.—(W. H. Walmsley.)

Simple Apparatus for Photo-Micrography.—This apparatus is for use on an ordinary camera, its chief advantage over the use of a microscope with the camera being that the ordinary use of the microscope is not interfered with, so that objects can be examined in the latter, and selected parts be immediately photographed. A brass disc or adapter, *a*, shown in section in Fig. 96, screws into a flange on the camera, and has a screw-threaded aperture to receive ordinary object-glasses. The disc carries a triangular rod, *b*, about $3\frac{1}{2}$ in. long, on which a square stage, *c*, slides, or can be clamped in any position by a screw, *d*. The stage has a central opening for light, and springs for holding a slide. The back of the camera is movable to a distance of 20 in. by a screw; but an ordinary quarter-plate camera, with a rack and pinion, serves almost as well, the magnification then obtainable being less, owing to the shortness of such cameras. Focusing is effected by clamping the stage so that the object is approximately in focus, and then moving the back of the camera as found necessary. This apparatus has been found to work very well with low powers, the illumination being effected by a paraffin lamp with one wick, the flame of which is focused on the object by stand condensers, with a blue cell interposed. —(T. H. Muras.)

Fig. 96.

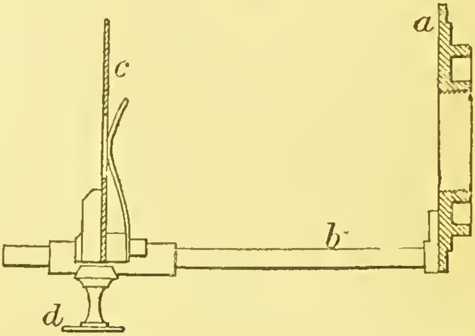
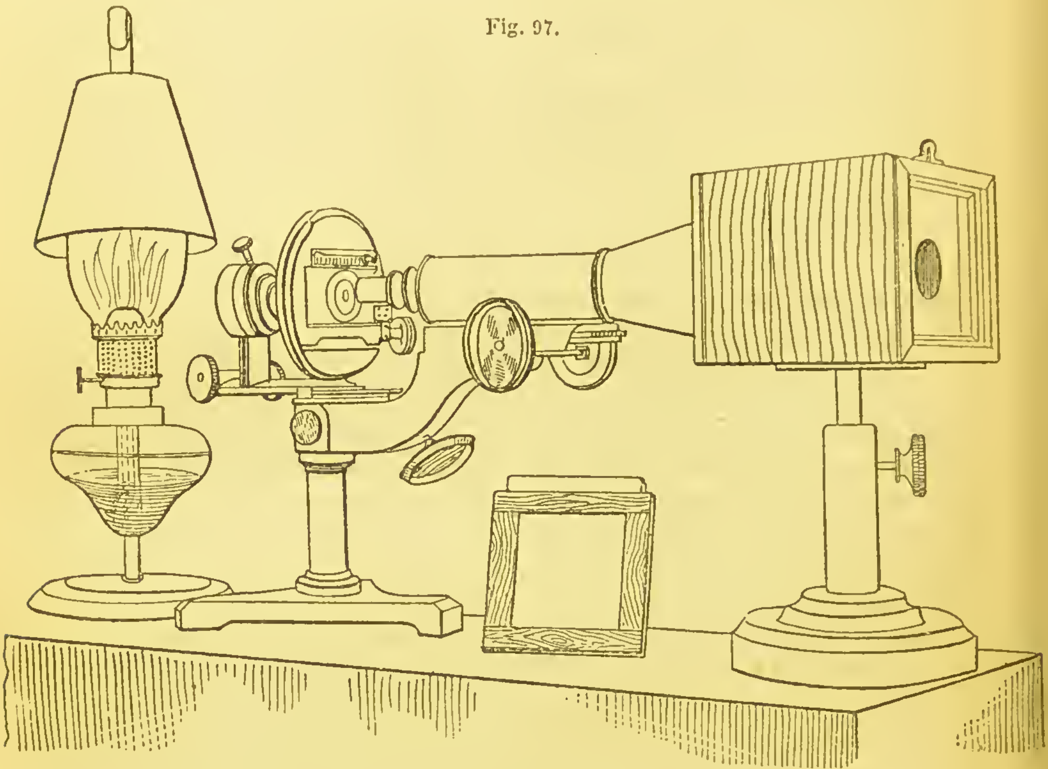


Photo-Micrographic Camera. — The student frequently finds in the course of his observation upon living and other tissues, features that are vital towards proving the truth of his researches, but so evanescent, that the lapse of a few minutes may suffice to obliterate them. A small simple camera which can be at once applied to the microscope, without the slightest alteration of the latter, save inclining the body to a horizontal position, using the same source of illumination, be it diffused daylight or that of the ordinary lamp, would be a boon. Fig. 97 shows such a camera.

The camera consists of a mahogany box about 2⅝ in. square, corrugated and blackened on the inside to prevent any reflections of light. A solid cone some 4 in. long, tapering to receive the tube of the microscope, is attached to the front of the box. Preferably, this cone-front should be in bellows form, as in the figure shown; but being rather more costly than the solid cone, many will be satisfied with the latter. In the one case the bellows responds readily to the movements of the microscope tube in focusing; in the other the tube must slide readily into and out of the solid cone. At the opposite end of the box is a groove, in which the plate-holder and frame containing the focusing screen slide. The former carries two plates 2½ in. square, amply large for all ordinary illustrations. Should larger sized pictures be required, they can be made by enlarging upon bromide paper.

Fig. 97.



The focusing-screen is made of very thin crystal glass, most carefully ground by hand, presenting the smoothest surface obtainable by this means, but still quite too coarse for the exact focusing of delicately marked objects. In fact, the focusing-screen is mainly useful in procuring even and full illumination of the field, and in properly centring the object. The final fixing of the exact focus is done by means of a focusing-glass used in conjunction with a disc of thin cover-glass attached to the ground surface of the screen by means of Canada balsam.

The camera is mounted upon a stout metal rod, which slides into the upright shaft of a very heavy japanned base, and can be secured at any height to suit that of the microscope (when the latter is inclined to a horizontal position) by means of a milled head. The base is shod with thick felt cloth, so that it may be placed upon any polished table-top without scratching the latter, and at the same time remain firmly fixed in the position it may be placed in.

And this is all there is of it: Simple, compact, always ready for immediate service, and occupying no appreciable space upon the work-table. Although primarily intended for use with the microscope body inclined to a horizontal position, it may be as readily adapted to the latter in a vertical one, when the character of the objects (as those mounted in fluids) may require. Remove the camera from its base and mount it upon the top of an open box containing the microscope. An opening in the top of the box allows the cone to be slipped over the tube of the microscope.

Illumination may be effected by reflection from the mirror as in ordinary work, or by removing the latter and placing the lamp behind the stage, and in a direct line with the optic axis. It must be carefully centred in order to illuminate the field alike in all portions. Condensers of various kinds—bull's eye, achromatic, Abbe, &c.—can be used as desired, but with moderate and low powers. The best results will be obtained by the employment of simple diaphragms of various sizes to suit, and so placed as to come as close as possible to the under surface of the slide upon which the object is mounted. All extraneous light should be excluded so far as possible, and none be allowed to enter the objective other than the rays which illuminate the specimen. Opaque objects may be photographed quite as successfully as transparent ones; but the time of exposure will be very greatly shortened by employing direct sunlight as the illuminant, if possible.

The eyepiece may be removed or not, as the observer may elect. The late Dr. J. J. Woodward almost invariably worked without it, using an amplifier where sufficient magnification could not be obtained with the objective alone. In using medium and high powers, the eyepiece is not objectionable; but with low powers, it certainly detracts from sharpness of definition, so that the amplifier is better where an increase of power beyond that obtainable with the unaided objective becomes necessary. If possible, however, always use the latter alone. The short tube-length, alone possible, renders the employment of amplifier or ocular necessary, if enlargements beyond 300–400 diameters are to be made, since the limit of a $\frac{1}{18}$' used direct is less than 350°.

The corrections of most modern objectives as to visual and actinic foci are so nearly identical, that no difficulty will be experienced in obtaining sharp definition of any subject if a little care be used.

The dry plates are furnished by the makers in two degrees of sensitiveness to suit every variety of subject. They are readily developed by any of the methods used for gelatine plates, preference being given to hydroquinon, or a mixture of that with eikonogen, as giving the clearest results, clearest details, and sharpest contrasts with any desired amount of density. Their cost is but 25 cents per dozen: certainly cheap enough to tempt any one to their use.

Bromide paper is the best material for printing in this class of work. Using the smooth surface-paper, and developing with ferrous oxalate, we get a perfect print, rendering the most delicate details with the crispness and clearness of a steel-plate engraving, which indeed it most closely resembles in very many instances. The exposure is made by lamplight, so that one is entirely independent of time and weather, and the finished print is absolutely permanent; as much so, it is reasonable to believe, as a carbon print. If the sheet be allowed to dry spontaneously, it will present the appearance of an ordinary plate engraving. If a polished surface be desired, all that is necessary will be to float the paper, print side down, upon a sheet of polished hard rubber; to squeeze it into optical contact, removing all superfluous moisture, and when quite dry it will peel off the rubber-plate with a beautiful polished surface, greatly increasing the delicacy of detail in many subjects, especially diatoms.

The ferro-prussiate, or more commonly named "blue-print" method of printing has decided advantages and merits for the work we are considering. It is cheap, as the paper may be purchased ready sensitised, at very trifling cost, and it requires no skill or experience in the using. It is merely necessary to expose to bright sunlight until sufficiently printed (a few experiments will determine this), and then to wash in several changes of water; the result being a bright, permanent blue print upon a clear, white ground, with excellent detail, excepting in the most delicate structures.

The negatives made with the camera are of a convenient size for priuting lantern slides by contact. A print on glass is certainly the most perfect of any that possibly can be made, and the importance of this method of demonstration has long since been conceded. Gelatine plates coated on thin glass with special slow emulsions, are furnished by several makers, and any microscopist can readily make his own lantern-slides with a little expenditure of time and patience. —(W. H. Walmsley.)

Landscapes by Moonlight.—Owing to the extremely feeble actinic force of moonlight, it is impossible to obtain instantaneous views by its aid, and a fully-exposed negative can be obtained only by large apertures of lenses of great luminous power, and by long exposure upon highly sensitive plates

The first moonlit picture exhibited publicly was at the Exhibition of 1851. On account of technical difficulties resulting from long exposures on wet collodion plates, the attempts made then were but rarely successful, and only after the introduction of collodion dry plates were more satisfactory moonlight pictures really possible.

Burton states positively that to photograph a landscape illuminated by moonlight requires from 300,000 to 3,000,000 times longer than the same landscape illuminated by sunlight. E. Von Gotthardt endorses what Burton says, and speaks of these facts more definitely when describing some experiments he made.

Eder speaks of an experiment by which he found the intensity of moonlight to be 6000 times weaker than that of a magnesium wire burnt in the focus of a concave mirror, and states, further, that he had made a moonlight landscape by an exposure of 3 hours upon a plate 20° Warnerke, with a Steinheil aplanate, stop $f/10$.

Henderson, under conditions similar to those of Eder, exposed for 7 hours, and Jahr had perfect negatives in 8 and 9 hours.

Dunmore obtained a very rich and harmonious moonlight landscape in 5 hours, and it is said that Colard and Holmer had the same results in 1–2 hours, while Causson and Co. exposed for 30 minutes with the full aperture of a portrait lens. The great difference of the times of exposure stated is owing mainly to the different forms of the objectives employed and their focal length, but is not at all contradictory to the principle laid down by Von Gotthardt. Causson and Co. used a portrait lens, and Jahr a Dallmeyer rectilinear, both with perfect success, it is said.

For scientific purposes, and as a technical object lesson to the photographer, the attempts at making pictures by moonlight are very instructive perhaps, and are otherwise interesting; but artistically they do not amount to much. Light and shade are not distinctly defined, as the motion of the moon obliterates all artistic effect in the prolonged exposure, and the finished picture reminds one of the works of Chinese artists, totally devoid of details, as well as of light and shade.

Moonlight photographs with distinctly pronounced shadows are impossible, and those claiming to be so are invariably made by daylight produced by a variety of clever printing and other dodges, and may be very beautiful so far as the moonlight effect is concerned. —(*Photo. Times.*)

Electro-Phototypy.—The process to be described only needs the experience gained in everyday work to render it a letterpress block process of high quality. The process is simply a means of direct electrotypy on a relief, produced on a gelatino-bromide negative, the electro being then passed on to the printer. Producing a relief on a gelatino-bromide negative dispenses with the use of collodion, with zinc or other surfaces sensitised with bichromated albumen and gelatine or bitumen, and with the difficult art of etching. It must be understood as distinctly referring to half-tone block work.

A gelatino-bromide negative is developed with alkaline pyro or hydroquinone, then fixed in strong hypo; when washed (care being taken the image does not absorb too much water), the plate is placed on a metal support and gradually heated to 212° F. This is very simple, and if tried, will result in an extraordinary production, the most probable being the shadows of the image running all over the plate. If we take a negative that has been impressed with a screen of some definite pattern, we get a very different result. Each little dot of the screen image holds an amount of reduced silver, bearing some definite proportion to the action of light and development; this is surrounded by a fine line, containing no silver, due to the opacity of the screen preventing any action. If we examine the little squares, we find the reduced silver has produced a certain amount of insolubility, the absorption or combination of the freed bromine with the gelatine a further amount, and a similar action due to the pyro. Now, on raising the temperature of such a film to the melting point of the part holding no silver, these portions melt, and are drawn by capillary action under the unmelted dots. This capillary action is evidently proportional in some way to the amount of reduced silver, and, therefore to the image. The importance of this consists in that the image becomes the actual regulator of the sizes of the dots; such being the case, we have the remarkable fact that the image is engraving itself, and the two operations of relief and graduation are proceeding at the same time. To understand the nature of this, it is necessary to remark that, in ordinary half-tone work, the endeavour is made to produce a graduated screen negative by optical means—well known to all who have studied the matter—and then reproduce from this graduated screen negative by etching in zinc or copper. The blocks are electros taken direct off camera negatives, some of them being produced direct from a silver print, and others from glass positives. The large electro is deposited by dynamo, and may be readily printed by any printer; the other blocks are deposited by battery, and require fine printing. It remains now to produce something between—a not very difficult matter at the present stage. —(H. Sutton.)

Photo-lithographic Transfers. — The usual method of making photo-lithographic transfers is upon gelatine made sensitive with potassium bichromate. This is quite sensitive enough to daylight, or to electric light; but if transfers are required when neither day nor electric light is available, then bichromated gelatine is useless, and some other method is wanted. Try this:—Make a print upon any of the ordinary bromide papers of commerce, using a good negative from a subject in line, by artificial light; develop the image with alkaline pyro, then wash and place it upon the inking-board; next, blot off the water with a soft cloth, and dab all over with a sponge saturated with transfer ink thinned with turpentine; let the turpentine evaporate, then take a glue roller—i. e. a type-printer's roller, and roll until the whites are quite clear of ink. Now soak the print in the pyro again for a few seconds, and expose it to the light. Finally, wash free from pyro and hang the print up to dry. When the print is dry it is ready for the transferrer, who treats it the same as he would any other photo-lithographic transfer.

The only way to fail with this method is to over or under expose the print, or to use a bad negative. The negative must show perfectly clear lines. Some of the newer papers of commerce contain too little gelatine to succeed perfectly, therefore it is best to make the paper at home. It is not a very complicated process, as the colour of the image under the developer is not all-important. A good formula is

Gelatine	800 gr.
Water	30 oz.

When the gelatine is quite soft, melt it at 120° F., and add 320 gr. ammonium bromide; stir it until it is dissolved, then add 10 m. hydrochloric acid and stir well.

In 10 oz. water dissolve 450 gr. silver nitrate, bringing this solution to the same temperature as the gelatine solution; now proceed to pour the silver solution into the gelatine in a very thin stream, stirring it vigorously all the time. Strain it into a warm dish, and tilt the solution so that it is only along one end of the dish. Having made a small roll of the paper, lay one edge of the roll upon the liquid, and as it curls take hold of it and lift it slowly up, when the paper will unroll itself, and receive a nice even coat of emulsion. Hang it up to dry, and repeat until all the emulsion is used.

For half-tone transfers, use calcium bromide and chloride, with 200 gr. extra gelatine, drying the paper at as high a temperature as possible without melting the gelatine. Paper with this emulsion upon it will be very hygroscopic, and must be kept very dry. Before use always dry the paper, and warm again before developing, so as to encourage the reticulation of the gelatine.

This paper is to be exposed under a half-tone negative, developed and washed, then inked up as directed for the line transfers, followed by immersion in the developer, and subsequent exposure to light, washing, and drying. To transfer to stone, trim with a pair of long shears, then put it into the damping-book until quite limp; then sponge the back of the transfer with a solution of oxalic acid 1 part, water 100. Take great care that none of this solution gets on the front of the transfer. Lay the sheet in position upon a cold, dry stone, and pull it through the press, with plenty of pressure, 5 or 6 times without lifting the tympan. The paper can be lifted off, leaving the image in ink on the stone. Gum it in, and leave it for 5–6 hours before rolling up.—(W. T. Wilkinson.)

Albert photo-lithographic Transfer paper.—Following is a detailed description of the photo-lithographic process in practical use in the most eminent printing establishments in Austria and Germany.

The bichromate bath consists of 1000 cc. water and 50 grm. potash bichromate. To this solution caustic ammonia is added until the reddish colour of the bath turns to a light-yellow colour; an excess of ammonia does no harm. The temperature of the bichromate bath should be about 66° F. It is filtered into a flat dish of sufficient size, and the paper, with the prepared surface up, is entirely immersed, and allowed to remain in the bath until it is quite soft. This is of importance, for if it is not soaked long enough, also if the temperature of the bath is below 66° F., the bichromate solution will not enter sufficiently into the prepared film, and consequently, at the subsequent inking up of the copies, the colour will adhere but badly to the exposed parts, especially to the broader lines and surfaces of the picture.

If sufficiently soaked, the paper is removed, held over the dish so that the fluid flows off only at one of the lower corners, and allowed to drain until the liquid only drops. Then the two corners of the paper, which have been held, are given to a second person, who now holds the sheet over a plate glass a little larger than the paper. This plate glass must previously be well cleaned, then rubbed in with talc powder, and the surplus of the latter dusted off with a broad soft brush. On this glass plate the sheet is placed with its lower edge on the prepared surface, and smoothed down by means of a soft cloth. During this operation, the person assisting holds fast the corners of the paper, until the mounting is finished, and only gives slowly way to the pressure of the smoothing down.

If too much of the talc powder has

been dusted off the plate glass, it may happen that the paper, after drying, partly adheres to the glass, and even tears here and there; it is therefore necessary that a certain amount of talc powder remains on the plate, and better too much than too little. Should the paper, after entirely drying, still adhere to some parts of the glass, then the latter has been badly cleaned.

Care should also be taken that in smoothing down the paper no air-bubbles arise between the glass and the paper, since they will appear on the dry paper in the form of matt spots, which will interfere in the case of fine work. As soon as the sheet lies quite flat on the glass, the back of it is well rubbed with a soft cloth, applying thereby a certain degree of pressure to suck up the fluid on the back of the paper, and also to squeeze out the bichromate bath between the paper and the glass, and by this means to accelerate the drying process.

The glass plate, together with the paper on it, is now placed in a darkened, not too warm room, and dried spontaneously; after 6–12 hours it will be dried. This may be ascertained by touching the back of the sheet, and by the paper easily stripping off.

After stripping, the paper shows a beautiful high gloss; it is now ready for copying, and must, of course, be kept in the dark. The sensitised paper should be used up within 24 hours, because if it is kept for a longer time it is more difficult to work. In the stripped state the paper should be kept in a not too dry place, for if it is too dry, or even brittle, no sharp copies are to be obtained with it since it does not join closely to the negative. Besides, it is important to preserve in the paper a certain degree of flexibility, because it will then be possible to open one half of the printing frame in order to control the progress of the printing process, without fear of obtaining a double print. Should it, however, occur that the paper is too brittle, it may be placed between slightly moistened blotting-paper, but care must be taken that the transfer paper does not become too damp.

In printing, it is not necessary to use a photometer, since it is possible to watch the progress by opening one side of the back of the frame, provided that the paper is sufficiently smooth. The print should have a brown tone, and appear in visible relief from the ground. Over-printing is very injurious, because the lines and points of the image become thereby broader, and the development of the copy becomes difficult. If, however, it is underprinted, the colour does not adhere to the image in development, or, at least, it adheres only to the vigorous parts of the print.

Care should also be taken that the backs in the printing frame are not damp, because this is obnoxious to the sharpness of the print. Sometimes it will happen, especially in the case of copies from densely-drawn originals, and in the case of copper engravings, that certain parts of the negative will print too quickly; parts of this kind are varnished on the back with carmine, as it is usually done in the case of negatives with half-tones.

The inking of the transfer may be carried on in different manners, but in all cases it is essential to lay on a light colour-tone evenly over the whole of the copy. This may be done by means of a sponge or a rag, as well as with a velvet roller; the main point is always the result. The manipulations are as follows:—The smooth face of a lithographic stone is, by means of an ordinary lithographic leather roller, inked up with good transfer ink, and the velvet roller, which perhaps serves the purpose best, is carefully charged with a thin coating of the ink; then the copy, which has been placed on an even, smooth surface, is inked up with the velvet roller until it is evenly covered with a middle grey tone. The vigorous parts of the image should still be visible through the colour, otherwise too much ink has been applied.

When the transfer is successfully inked up, it is placed in clean cold water, but care should be taken that no air-bubbles adhere to the copy in the water, and that the back of the paper remains completely covered with the water. After 10–15 minutes the transfer is removed, the water is allowed to drain, the copy is laid once more with its back on the smooth plate, and the water is squeezed out from the film side by means of fine tissue paper, which is done best by rolling over it with an old, clean lithographic roller, avoiding, however, carefully the formation of wrinkles, because, otherwise, the film will probably be damaged. The moistened transfer is now once more inked up with the velvet roller charged with colour. If, after some rolling, the image comes out quite distinctly, the paper, at the same time, being clear of the yellow colour produced by the bichromate bath, it is only necessary to wash off with a clean, very fine, and soft sponge moistened with water the colour which still adheres to the unexposed parts of the impression. If, however, the transfer, after being inked up, appears still yellow, it must be placed, before the application of the sponge, once more in the water, and the inking up with the velvet roller must be repeated.

The ready developed transfers are placed between dry, clean, and perfectly smooth blotting paper, and by gentle pressure freed from the still adhering water. Then they are fastened by means of drawing pins on a board, and dried spontaneously on a slightly warmed place free from dust.

The dry copy is placed between damp blotting paper. In the case of grained or stippled impressions, tissue paper must be used instead of the ordinary blotting-paper.

In pulling through the press for the first time, only a slight pressure should be applied, it being increased at each stroke. As usually, the transfer is several times wetted with water. After the last pulling through, the transfer is removed without again being wetted; if there is any difficulty in doing so, the stone may be taken out of the press, and placed for a short time in a cold room, or the transfer may be dried spontaneously. In both cases the removing of the transfer is facilitated..

The "rubbing-in" or intensifying of the image on the stone is done as usual, but in the case of very fine drawings, grained or stippled images, a very slow procedure will be necessary. The sponge which is used in intensifying should contain only a small quantity of the colour.

The etching may be done in the ordinary manner with slightly acid gum-water; in the case of fine drawings, however, it is recommended to apply a "sharp or high-etching" bath, it offering also otherwise some advantages.

For this purpose the transfer is dusted in at first with rosin powder, then with talc powder, and the excessive powder is carefully removed with a pad of cotton. Then two narrow, long strips of wood, about $\frac{1}{8}$ in. thick, are placed on the two longitudinal edges of the stone, clear of the impression, and fastened at one end in any convenient way. Then a wooden lath, about 3 in. wide, $1\frac{1}{8}$ in. thick, and a little longer than the stone is wide, is taken, covered with cloth, and moistened with sulphuric ether; it is then placed on the two wooden strips, at the end that has been fastened to the stone, and slowly pulled over the strips at full length of the stone. It is sufficient to go once over the stone in the manner described in order to melt the rosin powder, together with the colour, by means of the ether vapours. Then the stone is etched for about one minute with the gum etching bath, which should be strong enough, so that it slightly scums if poured on the stone. The stone is then ready to be printed from. With the same paper, transfers can also be made on zinc to produce relief blocks, and, indeed, it is used for this purpose by many large establishments.—(H. E. Gunther.) (See also ii. 183.)

Photo-Zincography.—For transferring photo-litho copies to zinc plates Albert gives the following method:—The copy is printed, developed with fatty ink, and dried as usual. The drawing is afterwards dusted in with a finely pulverised mixture of 10 parts asphaltum and 1 of pure beeswax, and all superfluous asphaltum is removed by means of a fine camel-hair brush and a tuft of cotton, and slightly heated over an alcohol lamp to melt the asphaltum together with the fatty ink. The copy is then passed through the saturated alum bath to keep it uniformly moist, laid between sheets of moistened blotting-paper, and finally transferred upon a zinc plate.

Zincography and Zinco Printing Plates.—The zinc plates for either process are sold ready polished, and differ only in thickness, the zinco block being four times as thick as those used for drawing upon. The zinc for drawing upon is not ready for graining until it has been washed with strong potash and rinsed in clean water, and the graining must be done with sand and water, in a manner similar to that adopted for the stone. If for crayon work, it must be very sharp in the grain, or it will not take the crayon. If for ink, in line or stipple, an inferior grain will do. In case of drawing anything that may require erasing, the zinc must on no account be scraped, as it would roll up solid black. It is better to take out with a piece of clean rag dipped in benzine anything that is wrong, and let it dry, when the crayon or ink may be used without fear over the same part. For convenience of working, the white portions may be stopped out as on stone, but the gum used should have a few drops of glacial acetic or nitric acid mixed with it to the strength one would use for a " strong etch " on stone.

When the drawing is completed, take a solution made as follows, and etch the plate with it for 10 minutes, not longer. Put 24 nut-galls into a saucepan—preferably one glazed with earthenware—and cover them with 1 pint water. Simmer over a slow fire until it is reduced to ½ pint or rather less. Strain through fine muslin into a clean vessel, and let it stand until cold; or it may be kept in a stoppered bottle. Take of strong gum and the above tincture of galls equal parts, and add a drop or two of glacial acetic or nitric acid. The former is preferable, as in washing the zinc acetate is more soluble than the nitrate.

This solution should be rapidly passed over the plate, whether chalk or lime, just as the " etch " over a stone. After 10 minutes' etching, wash off with a clean sponge and plenty of water, and roll up in the usual way, bringing it up with a roller. Some prefer to allow the plate to dry all over during the rolling up, and keep rolling until the whole plate is one black mass, when they wash out the job with "turps" and water and roll up again. Others are careful to prevent the plate drying in the white or clear parts by wiping very frequently with a very slight etch of gum and acetic acid, feeding the job with the roller all the time in between. If a transfer is required, a few impressions should be run off before again washing out, when the job will be found strong enough to roll up in retransfer (litho) ink, and the transfers pulled may be put down upon polished zinc for the bath.

Zinco blocks for letterpress printing must be polished, unless, perhaps, for coarse poster work. The grained surface would not answer in the printing. To polish the zinc, take the ordinary pumice powder, very fine, and, with a piece of soft, preferably linen, rag and a little water, rub it down till an even polished surface appears; after which, with the same powder, dry, complete the polishing till the surface reflects like a mirror. Immediately put the transfer down exactly as if it were stone; then, before rolling up, dip it in a very weak bath for a minute or so, and rinse and dry without heating. It should not be washed out, but rolled up in litho ink, and may then be put in the trough and rocked in the usual way, being heated from time to time, and rolled again with the ordinary varnish.

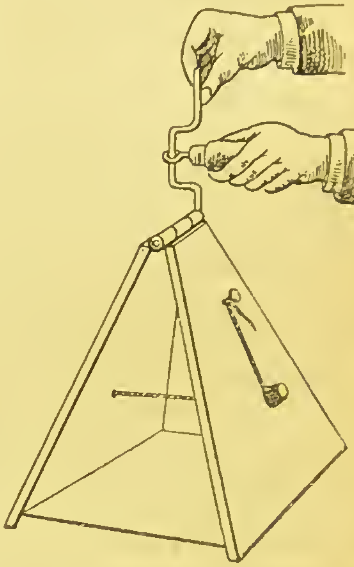
Sufficient care is not usually exhibited in England in biting up these plates for zinco blocks. In Paris the plates are carefully examined through a strong magnifying glass; and if any tendency to undermine the lines is shown on arriving at a certain depth, the operator takes a varnish brush and protects the shelving sides with it, and also touches up any parts of the surface which seem feeble. If any specks of "scum," or "dirt," adhere to the sides of the lines or among the chalking, he takes a graver and cuts them away, taking care to touch each graver out with varnish, so as to prevent the subsequent bath from undermining the line. To this care is due the superiority of the French, and for that matter, the American, process work.

Some houses, before subjecting the transfer on zinc to the weak bath, etch it with the tincture of galls and gum for 5–6 minutes, which will clear away all scum, and then rinse off with cold, clean water, and immerse in the bath.

Almost every operator has his own favourite mixture of ink for rolling up the zinco block during the biting up, which he pretends to keep a profound secret. But anything which will feed the job, and prevent the acids in the trough from impoverishing it, will answer the purpose satisfactorily. Cobblers' wax, rosin, and white or yellow wax, all of which are rendered fluent by the heated plate, in various proportions of admixture, form the bases.

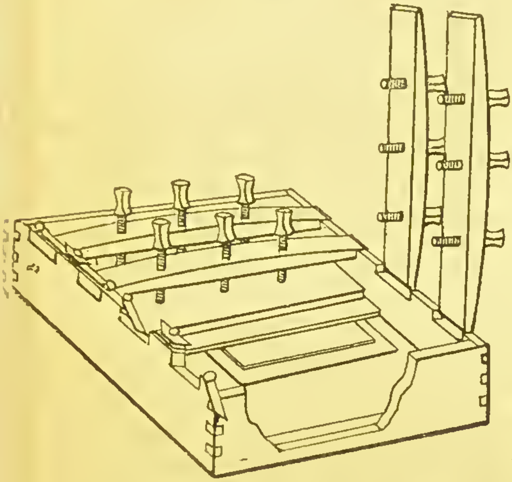
Swain's Photo-Zinco Works.—At his photo-zincographic works in Farringdon Street, the clean zinc plates are first coated with diluted albumen, and then with a solution of albumen in water, to which some potash bichromate is added. This is evenly distributed over the plate by means of the whirler, represented in Fig. 98; the zinc plate is placed face downward in the jaws of the whirler, as represented in the cut. When face downward it is less liable to be deteriorated by particles of dust settling upon its surface, and the surplus liquid is removed with more facility. That the latter may run off all the more easily, the plate does not rest in grooves in the boards holding it, but upon the ends of nails driven through from the outside of each board. The plate is whirled, centre-bit fashion, 15–50 seconds, according to the viscosity of the liquid used in any particular process. With diluted albumen, the whirling is of short duration, and a perfectly even, very thin coating is obtained. In some works a whirler with a larger handle is turned by "knack" with one hand only. The operators in such cases fancy that the eccentric motion then also given to the plate is advantageous; but this is questionable. The wet solution of potash bichromate, albumen, and water is not sensitive to light, but when the film is dry the reverse is the case. Hence the drying over a small gas-jet is effected in non-actinic light. The effect of light is to partially deoxidise the potash bichromate; a chromium oxide insoluble in water is thrown down in the film, all the rest of which, where light has not acted through the negative, can be dissolved off in water. This process does not give half tones; it is suitable only for line drawings, or subjects in black-and-white.

Fig. 98.



The printing frames used by Swain are of a special description, and permit the application of much more pressure than those used in ordinary photography. One of them is represented in Fig. 99; its glass plate is 1 in. thick, and this is not in practice found to appreciably increase its liability to be cracked by the near proximity of the electric arc used in printing, perhaps because it is annealed with great care. In the cut the glass negative is represented upon the glass of the frame, and upon the negative is the zinc plate. Then comes the hinged back of the frame, with cross bars and strong screws for screwing all the surfaces together. When the plate is thus secured behind the negative, the frame is turned up, and the zinc plate is exposed to light behind the negative.

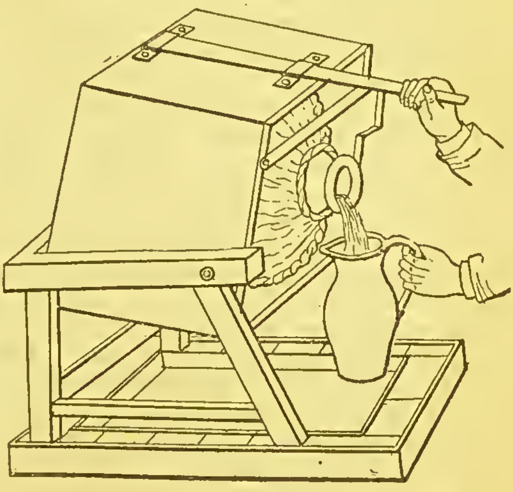
Fig. 99.



When removed from the printing frame, the plate is inked, and washed for a few minutes to remove the potash bichromate from the portions unacted upon by light. It is next treated with solution of gum arabic, after which the image upon the plate will take ink. It is under the gum solution for 10 minutes, and is then washed. Afterwards the plate is inked with a very greasy ink, and sent to the etching department, in which it is briefly immersed in a very weak solution of nitric acid, and then sent down to the artists' department, that any defects in the image, which are rarely present, may be removed by hand. It is then sent upstairs again for deeper etching. The image is inked by means of a perfected lithographic roller, with greasy ink, dusted with rosin and heated on metal slabs, then the plate is put in baths of special Doulton ware, containing highly diluted nitric acid, and the baths are rocked by hand upon wooden cradles while the acid is eating into the metal. Every now and then the plate is taken out, inked, rosined, and heated afresh, then replaced in the etching bath. This frequent varnishing of the image is given to prevent the acid eating its way under the lines of the engraving, which under the system adopted stand up from the rest of the plate like little ranges of hills of exceedingly small elevation. An average plate takes about 4 hours to etch.

Nitric acid is used in the etching rather than hydrochloric acid, because it works quicker; and as carboys of nitric acid are unpleasant and somewhat dangerous things to handle in workshops, the carboy in use is mounted in the wooden frame—Fig. 100—in which it can be more conveniently manipulated.

Fig. 100.



The negatives for photo-zincography are usually taken by the old wet collodion process, as strong a contrast in them as possible of black and white being desired; but great density is of less importance than absolutely bare glass in the lines of the image. A good negative for the purpose, according to W. J. Wilkinson, an authority on the subject, should show all the lines of the image when it is laid down flat on a piece of white paper. When the lines are then quite clear, excessive density in the black is not so necessary as sometimes supposed. A few brands of the slower gelatine dry plates in the market will do for photo-zincography,but the old wet process is more economical.

The intensification of the fixed negative, to make it deep enough for printing, is effected by lead ferricyanide. Swain's exact formula is not known to us, but Dr. Eder and Captain Toth, of Vienna, who discovered the method, proceeded as follows:—The fixed and well washed negative received a washing with distilled water, then was plunged in a bath consisting of lead nitrate, 100 grm.; red prussiate potash, 5 grm.; distilled water, 5 grm. In this bath it remained until it became quite white, then it was well washed, and flooded with a 20 per cent. solution of ammonium sulphide; when the film then became blackened through, it was thoroughly washed again, and the negative was finished.

The method of intensification used at Brussels in the production of negatives for Belgian ordnance maps gives intensely black negatives, and avoids the use of ammonium sulphide. The agent used is copper bromide. By this method 120 gr. copper sulphate are dissolved in 1 oz. water, and 125 gr. potassium bromide are dissolved in as small a quantity of water as possible. The two solutions are then mixed, and the plate is flooded with the mixture. When the image becomes of a greenish-grey colour, the liquid is poured off, the plate is well washed, then washed with distilled water, after which a solution of 100 gr. to the oz. of silver nitrate is made to cover it at one sweep. These operations may be repeated if necessary, but intense blackness is usually obtained by the first treatment. The only objection to this process is the considerable amount of silver nitrate it uses up, but in all large photographic establishments the silver is finally recovered, so this process is much used. Warnerke found that the application of soda sulphantimoniate in place of silver nitrate gave a red image.

Colour Photography.—Ives recently explained and illustrated some improvements he has made in the means of operating the process, by which it is rendered comparatively simple and capable of immediately profitable commercial operation for lantern illustration. Ives showed that, by an improvement on his helio-chromic camera, the three negatives, representing the effect of the object photographed upon the three fundamental colour-sensations, are now not only made from one point of view by simultaneous and equal exposure, but also upon a single sensitive plate, so that the helio-chromic negative is obtained with no more trouble than an ordinary one, and any number can be made in which the relation of one element to the others is exactly the same. The colour-prints also can be made from these negatives by a single exposure in transparent gelatine, and separated only when ready to dip into the dye solutions representing the respective colour-sensations. It is not necessary to go to the trouble of making the colour prints when only lantern illustrations are required. Lantern positives, made from the helio-chromic negatives, with no more trouble than ordinary lantern-slides, can be projected on the screen in the natural colours in the ordinary lantern by means of a special front, substituted for the ordinary projecting lens in about one second, so that an exhibition of ordinary lantern-slides can be interspersed with projections in natural colours without causing any delay in changing from one to the other. The approximation to the colours of nature is marvellously accurate. The positives are about one-third smaller than the ordinary projections; but as sharply defined, and in as bright and true colours, as those produced with the more elaborate and troublesome lantern. The lantern front used for these new projections consists of three prisms, converging light from a single condenser and radiant to three small projecting lenses, the necessary colour screens being located just behind the objectives. Ives also has devised a camera to produce the helio-chromic negatives, in which three negatives are made on a single plate, the image-forming rays being transmitted to the single gelatine dry plate through three reflecting prisms, and from points of view so close together (less than ½ in. apart) as to make perfect registration easy of accomplishment. By another camera the three negatives are made from the same point of view.

Photography in Aniline Colours.—The recent discovery by Cross, Bevan, and Green of a new process of colour-photography is not a method of photographing in natural colours, but one which gives a means of producing prints in a great variety of tints.

During a certain course of tuition, it became necessary to illustrate visibly the action of light, and for this purpose were used some of the aniline dyes which fade in the light when treated with nitrous acid. The idea then occurred to utilise this fact for photographic purposes, finally resulting in the production of prints upon silk, cotton, woollen, velveteen, and other fabrics in seven colours—red, maroon, yellow, orange, brown, purple, blue—and in the shades produced by an admixture of these colours.

The material, which is of primary importance, is primuline. This is a yellow substance discovered by Green in 1887; he obtained it by the action of sulphur upon paratoluidine—one of the coal-tar bases closely allied to aniline. At least two bases result from this reaction, and the sodium salt of the mono-sulphonic acid of the more complex of one of these has the peculiar property of dyeing unmordanted cotton a fast primrose-yellow. This product is largely employed in cotton-dyeing on account of the great range of fast shades that may be obtained with it.

Primuline, in common with all coal-tar bases, combines with nitrous acid to form a species of nitrite, which is termed a "diazo-compound." All that need be noted about this diazo-compound is that it corresponds to the intermediate stage in the transition of ammonium nitrite to the condition of nitrogen (and water) thus:—

		INTERMEDIATE STAGE.		FINAL STAGE.
$NH_3\cdot HNO_2$ Ammonium nitrite.	$\longrightarrow$	$H\cdot N:N\cdot OH$ (by subtracting one molecule of water).	$\longrightarrow$	N_2 (by subtracting two molecules of water).

With this compare:—

$$X\cdot N:\overset{|}{N}\cdot OH$$

Diazo-primuline.

In other words, when ammonium-nitrite is decomposed by heat, first one molecule of water is abstracted, leaving $H\cdot N:N:OH$ (the intermediate stage), and then another is taken away, leaving only nitrogen (the final stage). With this intermediate stage we may compare the constitution of diazo-primuline.

The symbol X in the formula $X\cdot N:N:OH$ really stands for a very complicated group of atoms, which, however, it will serve no useful purpose to consider here.

Now, although primuline is very stable under the action of light, the diazo-compound—namely, diazo-primuline—is very sensitive, and readily undergoes decomposition, giving off nitrogen gas—that is to say, just as ammonia nitrite, under the decomposing influence of heat, gives off nitrogen, so diazo-primuline, under the influence of light, also evolves this gas. Further, it and similar compounds obtained from other dyes of the primuline groups, have what has been called a great avidity for constructive reaction with two large groups of coal-tar compounds—the amines and the phenols. With these they chemically combine, and the products are the azo-colouring matters.

The more important of the azo-colouring matters obtained from primuline are seen in the following scheme:—

Primuline and nitric acid
give
Diazo-primuline
and
Diazo-primuline
with

Beta-naphthol	Phenol	Resorcin	Pyrogallol	Alpha-naphthylamine-hydrochloride	Amido-beta-naphthol-sulphuric-acid
gives					
Red	Yellow	Orange	Brown	Purple	Blue

colours respectively.

All the diazo-compounds can be employed for photographic purposes, and their normal sensitiveness to light is increased by combination with the complex colloids which constitute animal or vegetable textile fabrics.

In the case of primuline, the essential conditions necessary for its photographic application are the following:—

(*a*) That the reactions above described take place after the application of the primuline to the surface of such material as wool, silk, &c., as a dye, without in the least affecting its union with the elements of this material.

(*b*) That the diazo-compound produced in combination with these materials by treating the primuline-dyed surface with nitrous acid is photo-sensitive to a high degree.

Although the chemical reactions are rather difficult to follow, the practical working of the process itself is extremely simple; it can be done by any intelligent person; no elaborate apparatus is necessary, nor are the materials either harmful or expensive. It consists of four stages, namely:—

1. Dyeing or coating the surface upon which it is required to photograph with a particular compound.

2. Converting the applied compound into a photo-sensitive derivative.

3. Exposing the surface thus prepared to light under the usual conditions for producing the picture.

4. Converting the sensitive compound wherever it survives, through having been protected by the shadows of the object photographed, into colouring matters—shades of red, orange, brown, purple, or blue, which are stable and fixed.

The apparatus required consists of a few glass beakers or small basins, a photographic printing-frame, a sheet of glass exactly fitting this frame, and a few glass stirring-rods. Having procured these, and the necessary chemicals, which are so cheap that a square yard of material can be treated at the cost of one farthing, the remaining operations are as follows:—

The material, say a piece of silk, is dyed in a hot solution of primuline, containing 1–2 per cent. of this substance, to which some common salt has been added, causing the whole to take a primrose-yellow colour. The silk is allowed to soak in this liquid for about ½ minute; it is then taken out, washed in cold water, and placed for another ½ minute in a cold bath containing sodium nitrite (¼ part to 100 of water) which has been acidified with sulphuric acid. This bath changes the character of the primuline; it diazotises it, and makes it thus extremely sensitive to the action of light.

The silk is now ready to receive the picture; that is to say its surface is now ready for exposure, and such a surface will give a complete positive picture after 40–180 seconds exposure.

Since every one may not possess a photographic positive, let us assume that it is desired to have printed on the silk a fern-leaf in a purple colour. To attain this, the printing-frame is laid upon its face on a table, the back taken out, and the sheet of glass (well cleaned) is placed in it; upon the glass the fern-leaf is placed, and then the sensitised silk above it. The back of the frame is put in place and secured by the usual springs, and then the face of it is turned towards a good light.

As the light falls upon the uncovered part of the diazo-primulined silk, it destroys the colour, and when that action has proceeded sufficiently far, the silk is taken out of the frame, the image of the fern-leaf will now be seen in a faint yellow colour upon the surface. In the bright lights the diazo-compound will be completely—in the half lights only partially—decomposed, so that a perfect reproduction of the original is obtained in the form of diazo-primuline.

While the printing process is proceeding, the developing-bath can be prepared. It consists, for this particular colour (say purple) of a solution of alpha-naphthylamine hydrochloride containing $\frac{1}{4}$ per cent.; but the picture can be developed with any of the various amines or phenols, which form a dye with the diazo-compound, if any other colour is wanted.

Into the developing-bath the prepared silk is plunged, and immediately pushed well down beneath the surface with one of the glass rods. In a few seconds the image of the fern-leaf will become changed from a faint yellow to a rich purple hue.

The whole process is now completed by well washing the material in cold water.

The development of colour corresponding to the shadows and half-tones of the object photographed is exactly proportionate to their depth, to the degree of protective action which they have exerted on the sensitive surface beneath—in other words, to the quantity of diazo-primuline which survives the decomposing influence of the light.

Should several leaves or flowers form the pattern, each can be developed in a different colour, after printing, by applying different solutions of amines or phenols to the different flowers or leaves by means of camel-hair pencils. Hence, in some cases, even something like the natural colouring can be followed.

Another way in which this photographic process can be utilised for decorative purposes is in making glass transparencies in various colours. Here the operations are perhaps slightly more difficult, in so far as it is necessary. in the first place, to coat a piece of glass of the required size, and which will fit the frame, with a thin film of gelatine, which has previously been mixed with a little of the primuline. When the film is dry, the prepared glass is treated exactly in the same way as in the case of the silk, except that the time for which it is left in the baths is necessarily more prolonged to enable the solutions to thoroughly saturate the gelatine. As we have already seen, nitrogen gas is given off as the diazo-compound decomposes under the influence of light, and unless the gelatine be sufficiently well soaked the tiny bubbles of gas will be entangled.

The prints obtained in this way are "positive," the lights and shadows in the object being faithfully reproduced in their true value in the coloured picture. Natural objects of convenient size and form may therefore be photographed directly. Reproductions from camera-pictures require glass positives or positive paper prints, such as over printed bromides, made transparent in the usual way with vaseline.

If only one solution is used in developing the picture, it will, of course, be a "monotint," just like any other picture by any printing process would be.

In the case of the primuline prints, one feature, apparently unavoidable, is the more or less yellow background which they possess; but it is possible to get prints with other bodies of this class, which give a very satisfactory approximation to a colourless background.

A primuline print is more nearly a measure of the visual intensity of the sun's rays than the sensitive films used in the ordinary methods of photography, in relation to which it is well known that the photographic intensity of sunlight is a very different thing to the visual intensity, owing to the enormously greater activity of the blue and violet rays in decomposing the compound which they employ.

The experiments have already brought to light the following new and important facts:—

1. The action of the light consists in the decomposition of the diazo group, with evolution of nitrogen, probably with the formation of the corresponding primuline phenol.

2. The rapidity of the action of the light varies, other things being equal, with the nature of the substance with which the diazo compound is combined.

3. Photographic reproductions of the spectrum show that as regards intensity of action the various rays of light are not in the same order as that in which they stand with reference to silver bromide, chloride, &c.

Taking into consideration the extreme simplicity of the process, the cheapness of the materials and apparatus, the fast nature of the colours, the scope it affords for artistic taste, and the almost endless purposes for which it can be used, it should be widely adopted. (*Eng. Mech.*)

Another process has been patented by Dr. Feer, and the invention is based on the fact that diazo-sulphonic salts $(R - N = N - SO_3Na)$ with phenol alkali, and chlorides of or free aromatic amines, react under the influence of solar or of the electric light, forming an azo dyeing substance. For carrying out the process, the inventor impregnates paper or textile fabric with a dilute molecular mixture of a diazosulphonic salt (for instance, of aniline, amidoazobenzole, benzidine, and their homologues) and phenol alkalies (for example, phenol, resorcin, and beta-naphthol) or chloride of or free amines (aniline, naphthylamine, phenylendiamine, and homologue). The paper or fabric is then dried in the dark, and exposed for about 5 minutes to the sun, or to the electric light. Thereby is formed in the illuminated portions an insoluble azo dye, while the parts protected by the opaque portions of the negative remain in their original colourless and soluble condition. The picture is thus developed while printing. It is, after exposure, washed with water, or with very dilute hydrochloric acid, whereby the unaltered sensitive preparation is washed from those parts not affected by light through the negative. The picture is thus fixed, and only requires drying to finish it. The following are some examples of mixtures with which the paper or fabric is treated:—

1.—Toluoldiazosulphonate of soda	25 grm.
Beta-naphthol	25 „
Caustic soda	8 „
Water	1000 „

2.—Ditolyltetrazosulphonate of soda	25 grm.
m-Phenylendiamine ..	8 „
Water	1000 „

3.—Ditolyltetrazosulphonate of soda	25 grm.
Resorcin	22 „
Caustic soda	16 „
Water	1000 „

The following examples will illustrate the application of ditolyltetrazosulphonate of soda mixed with resorcin and alpha beta-naphthol respectively, and phenylendiamine.

Preparation of the Solutions.

1.—Ditolyltetrazosulphonate of soda	30 grm.
Resorcin	20 ,,
Caustic soda	15 ,,

All, finely powdered, are dissolved by gentle heat in one litre of water.

2.—Ditolyltetrazosulphonate of soda	30 grm.
Alpha-naphthol	25 ,,
Caustic soda	7 ,,

Dissolved in one litre of water.

3.—Ditolyltetrazosulphonate of soda	30 grm.
Phenylendiamine	20 ,,

Dissolved in one litre of water. The solutions 1 and 2, or 2 and 3, may be mixed in equal parts. The paper is impregnated with the above mixture, and then exposed for 10–15 minutes to direct sunshine. After exposure, the picture is washed with very dilute hydrochloric acid, then with water, and finally dried.

In Lippmann's process the sensitive materials, the developers, and the fixing agents are similar to those which have been in use for many years. Lippmann does not introduce any radical chemical change; he merely modifies the physical conditions of ordinary photography, and any one who possesses a general acquaintance with the common laws of light ought to have no difficulty whatever in following out the *modus operandi* of colour-photography.

The essential conditions that must be present in order that colour effects may be successfully produced upon the sensitive plate are two—namely, the presence of a reflecting surface situated at the back of the photographic film, and the absolute continuity of this film; that is to say, the absence of any granules in it.

Whatever the sensitive agent employed may be (silver iodide, bromide, &c.), it must be so uniformly distributed within the film of gelatine, albumen, or some other transparent or inert material like collodion, that no granules are formed that can be recognised even by means of a powerful microscope. Or, if any granulation does take place the dimensions of the granules must, in order to secure success, be so small that they are insignificant and negligible in comparison with the length of the waves of light.

Great care appears to be necessary in preparing the sensitive plate in order to obtain this essential condition of continuity.

When common albumen plates are used, Lippmann recommends that the coating be somewhat thicker than is usually thought necessary, while, if "Taupenot" plates are resorted to, a double or even a triple layer of albumen is required.

The best success has hitherto been obtained with silver gelatino-bromide. Lippmann uses the following formula:—Pure gelatine, 10 grm.; potassium bromide, 1·5 grm.; distilled water, 100 grm.

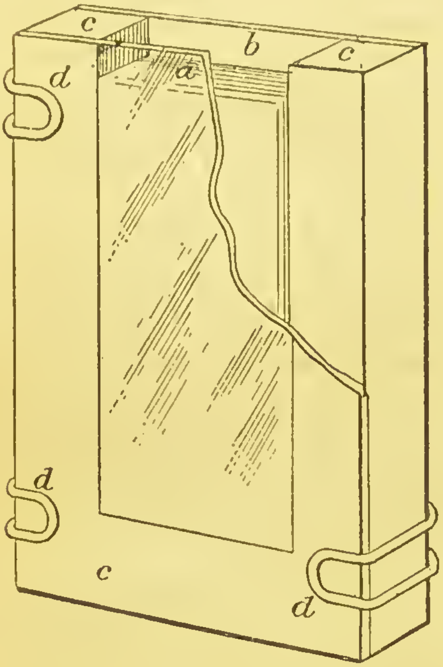
The potassium bromide and the gelatine are dissolved in the water, then filtered, and the solution is spread upon the glass plates to the required thickness.

When the plates are quite dry, they are sensitised for at least 5 minutes (a longer time is better) in a solution of silver nitrate, containing 20 per cent. of this salt and a little acetic acid; after that they are washed thoroughly, and carefully dried. They are then ready for use.

In making a heliochrome, the sensitised plate is put into a hollow frame, or trough, into which mercury can be placed in such a way that it forms, as it were, a background to the sensitive film, or, in other words, a bright reflecting layer in close contact with the film.

Fig. 101 is a view of one of these frames fitted up ready for exposure. Here *a* is the sensitive plate placed in direct contact on the film side with mercury *b*. A piece of glass forms the back of the frame. The sides are closed in by a U-shaped piece of rubber *c*, which is rectangular in section. The component parts of the frame are all held tightly together by means of four strong clips *d*, three only of which are shown, as a portion of the front of the frame is supposed to be cut away to show the interior.

Fig. 101.



Lippmann has chiefly been successful in taking photographs of spectra, although he has also taken some stained-glass windows of simple pattern.

The exposure, the developing, and the fixing operations are performed as if it were intended to obtain a black negative; but the result is different, for when the proof is finished and dried, the proper colours of the object photographed duly appear.

The proof obtained is negative when viewed by transmitted light; in other words, each colour present in the object photographed is represented by its complementary colour. When viewed, however, by reflected light, the proof is positive—that is to say, the image appears to represent the actual colours of the object.

Lippmann has chiefly used slow plates that are not orthochromatic, and the time of exposure has varied from ½ hour to about 2 hours. This long period of exposure is necessary in order to give the red rays a chance of exerting their full effect.

The process of developing is performed with pyrogallol and ammonium sesquicarbonate, in a manner similar to the method of developing "Taupenot" plates.

After being treated a sufficiently long time with the "developer," the plates are thoroughly washed with water, then with a very dilute solution of common salt, and finally fixed with ordinary hyposulphite.

When this treatment is carefully followed out, Lippmann states that the plates are quite stable, and even when exposed to the action of the strongest electric light the character of the colours is unchanged.

The theory of this process of colour-photography is very simple; it depends upon the well-known phenomena of the interference of light.

PLATING.

The first and most important operation in all branches of the deposition of one metal upon another, is to effect a thorough and chemical cleansing of the surface of the metal upon which the coating is to be deposited.

Cleansing Copper and its Alloys.—This is done in six operations. (1) Cleansing by fire or by alkalies. (2) Dipping. (3) Dipping in old aquafortis. (4) Dipping in new aquafortis and soot. (5) Dipping in compound acids for a bright or dead lustre. (6) Dipping in nitrate of binoxide of mercury.

By Fire or by Alkalies.—This is to remove any foreign substances, especially those of a fatty nature, which are destroyed by heating the pieces in every direction over a gentle fire of charcoal, breeze, or spent tan. A muffle furnace, heated up to a dull red heat, is preferred; but small articles may be cleansed in a hot revolving cylinder. This operation is not adapted to very delicate articles, or for table-forks and spoons, which must keep their toughness, or to those pieces in which the different parts are united by soft solders. Boil such articles in a solution of potash or soda, which renders the fatty substances soluble in water. This is done in a cast-iron kettle, provided with a cover, containing a boiling concentrated solution of carbonate of potash or soda, or of caustic alkali. The caustic potash or soda must be dissolved in ten times its weight of water. This solution lasts a long time; when it has lost part of its power, it may be revived by a few fragments of caustic alkali. At the boiling point it will cleanse copper in a few seconds. If the articles to be scoured are joined with tin solder, they must not be allowed to remain too long in the caustic liquor, which would dissolve the solder and blacken the copper.

Dipping.—The pieces are then dipped in a mixture of 5–20 parts in weight of sulphuric acid at 66° B. for 100 parts of water. Most of the pieces to be cleansed may be dipped hot in this mixture; but certain alloys, in which tin, zinc, or antimony predominates, such as cast bronze, must not be so treated, as the sudden cooling will occasion cracks and flaws. Copper articles may remain any length of time in the dipping bath; they should not be removed before the black coat of copper binoxide, caused by the heating, is entirely dissolved. The remaining coat of red copper protoxide is unacted upon by the sulphuric acid. Articles having parts made of iron or zinc must not be submitted to the action of dilute sulphuric acid, or they will be entirely dissolved; therefore avoid the use of implements or wires of iron, zinc, or steel. A dipping bath which contains copper in solution from previous operations will not suit for articles which may contain iron, tin, tin solder, antimony, bismuth, or lead. In such a case, use a newly-made dipping bath and a small proportion of acid. Articles which have been cleansed by alkalies must be washed before being put into the dipping bath, or pickle. Thorough and rapid rinsing in fresh water, before and after each of the following operations, must be strictly attended to. The various manipulations which complete the cleansing succeed each other without interruption; and the articles must be stirred as well as possible in the acid baths, and in the rinsing water. After dipping and rinsing, the various pieces are fixed to a brass wire, or hooked upon brass or copper hooks. Small articles of jewellery are suspended to a stout copper wire. These hooks are better if made of pure copper than of brass, and it is still better to use glass hooks, which are cheap and are not corroded by the acids. Such hooks or supports can be made by bending glass rods, by the heat of a charcoal fire, or of a gas burner, to the desired shape. Those objects which cannot be suspended or attached to hooks, are put into perforated ladles of porcelain or stoneware. It is less economical, but sometimes absolutely necessary, to use baskets of brass or copper wire cloth. Those who frequently have to cleanse very small articles will find it advantageous to employ a basket of platinum wire cloth, which, although expensive in the first cost, will be found cheaper in the end, as it is almost indestructible.

Dipping in old Aquafortis.—If you have any aquafortis (nitric acid) already weakened by preceding dippings, plunge into it the articles which have passed through the sulphuric acid pickle bath, and have been rinsed. They may remain there until the red coat of copper protoxide has entirely disappeared, leaving, after rinsing, a uniform metallic lustre. The dipping in old aquafortis, though not absolutely necessary, is recommended for two reasons; it economises the cost of fresh acids; and, as its action is slow, it prevents the too rapid corrosion of the cleansed copper during the time of the solution of the protoxide.

Dipping in Aquafortis and Soot.—After rinsing in fresh water, the articles are well shaken and drained, and then plunged into a bath composed of 100 parts nitric acid at 36° B., 1 common salt, 1 calcined soot. This mixture attacks the metal with the greatest energy, and the pieces should therefore not remain in it more than a few seconds. The volume of acid should be about 30 times that of the articles to be cleaned, in order to prevent too great an elevation of temperature due to the chemical reaction, which would result in the rapid weakening of the acid. After this bath, and rapid rinsing, in order to prevent the production of nitrous vapours, the pieces present a fine red lustre, gold-yellow, or greenish-yellow, according to the alloy employed, and such as to make one believe that they are entirely cleansed of foreign matter; yet if the pieces in this state are plunged into a gilding or silvering bath, they become entirely black, and without any metallic lustre. If the pieces are put aside without rinsing, there rises on their surface a green froth and nitrous vapour, which indicate the decomposition of the acid with which they are contaminated. When the vapours have disappeared, the pieces, even after washing, remain of a dull black, on account of the formation of a basic copper salt which is not soluble in water. This last mode of operating, called blacking by aquafortis, is preferred by a few gilders, varnishers, and colour fixers, who find it economical to allow the production of nitrous vapours while the pieces are draining on top of the vessel which contains the acids. Any subsequent operation is to be prefaced by a rinsing in fresh water. When small objects, such as pins, caps, or eyelets, are to be dipped, they are put into a stoneware pot, with a small quantity of aquafortis, and then rapidly shaken and stirred. In this case the acid is entirely used up with the production of abundant vapours, and the objects remain blackened, and ready for a further cleansing. Care must be taken in the choice of aquafortis. Three kinds of nitric acid at 36° B. are to be found in the trade. One is perfectly white, another is straw-yellow, and another is more or less dark-red. The white acid, without nitrous gas, does not cleanse well, especially when freshly used. The red acid acts too powerfully and pits the copper. The straw-yellow acid is preferred to the others. Nitric acid at 40° B. is too energetic and costly; however, certain operators who have to cleanse large quantities of copper wares prefer it on account of the rapidity of the operation. The acid is spent when its action on copper goods becomes too slow, and when the objects removed from the bath are covered with a kind of bluish-white film. Such acid is preserved for the preceding operation, namely, dipping in old aquafortis; or for dipping in the whitening bath. Very good aquafortis may cleanse imperfectly when the temperature is too low or too high. This accounts for the difficulty of cleansing in frosty weather, or during the great heat of summer.

Aquafortis for Bright Lustre.—There is an excellent way of obtaining a bright lustre on surfaces which have been dulled or slightly pitted by defective cleansing, or by passage through acids for removing gold or silver. Place them for a few minutes in a bath composed of 1 part old aquafortis, nearly spent, 6 hydrochloric acid, 2 water. The pieces, when removed from the bath, are entirely black, and must be thoroughly rinsed in water to remove the kind of black mud which covers them. They are then cleansed and dipped again. This bath will be found useful by electro-gilders. It is also convenient for removing the sand adhering to the castings of copper alloys. Large pieces may remain in the bath for 20–30 minutes, as this mixture acts very slowly on copper and its alloys.

Dipping in Compound Acids for a Bright Lustre.—These acids are of two kinds, according to the object in view. If the pieces are to have a bright lustre, they are stirred for 1 or 2 seconds in a liquid, prepared the day before, and cold, made of 100 parts nitric acid at 36° B., 100 sulphuric acid at 66° B., 1 common salt. In preparing this bath, nitric acid is first put into the vessel, and then sulphuric acid, which is much denser, and would not mix readily if it were put in first. At the time of mixing, especially when the salt is added, considerable heat and a quantity of acid and injurious fumes are produced, so that it is prudent to operate in the open air, or under a good chimney-hood with a movable glass sash. As these acids must be employed cold, it is necessary to prepare them in advance. Copper articles, after this dipping, are lighter coloured and much brighter than after the passage through aquafortis. They may then be considered as completely cleansed, and must be immediately rinsed in plenty of clean water. The above acids are too energetic for small articles, such as pins or hooks, which are generally cleansed in stoneware colanders. As the small articles stop up the perforations, the acid cannot run out so quickly as desired, and begins to heat and give off fumes, the pieces blackening before they can be rinsed. Therefore, for small pieces, add to the above mixture one-eighth of its volume of water. Place the articles in a stoneware pot; stir rapidly with a small quantity of bitters, as the last mixture is termed, and then the whole is plunged into a quantity of fresh water as soon as the acid has sufficiently acted. This method is not economical, as the acid is lost; but the dipping liquors do not become heated.

Whitening bath consists of old aquafortis, sulphuric acid, common salt, and uncalcined soot. Pour into a large stoneware vessel a certain quantity of old aquafortis from previous dippings, and then add twice the volume of sulphuric acid at 66° B. The mixture is allowed to cool off until the next day. The copper nitrate of the old aquafortis becomes converted into sulphate, which, by cooling, crystallises against the sides of the vessel. Decant the liquid portion into another vessel, and then add 2-3 per cent. of common salt, and as much of calcined soot. This mixture is much less energetic than the compound acids for a bright lustre, and often replaces them advantageously. The crystallised copper sulphate is collected and sold. This bath is strengthened, when necessary, by the addition of stronger aquafortis and oil of vitriol. To replace the portion used up during the day, equal quantities of old aquafortis and oil of vitriol are added at the end of the day. The next morning the liquors are decanted, and the copper sulphate is gathered. Soot and common salt in sufficient proportions are then added. In this manner a perpetual and cheap whitening bath is prepared.

Compound Acids for a Dead Lustre.—If it is desired to give the objects a dead lustre, they are, after dipping in aquafortis and rinsing, plunged into a bath, prepared previously, composed of 200 parts nitric acid at 36° B., 100 sulphuric acid at 66° B., 1 common salt, 1–5 zinc sulphate. Copper articles may remain 5–20 minutes in the cold bath, and the dead lustre will be the more apparent the longer the immersion has been. From this bath, after a long rinsing, the objects have an earthy appearance. This dulness is removed by a rapid passage of the pieces through the compound acids for a bright lustre, and by an immediate rinsing. If they remain too long in the latter acids, the dead lustre will disappear, and the operation for dead lustre will have to be repeated. If a bath for the bright lustre is not at hand, the objects, after rinsing, may be rapidly passed through the dead-lustre bath, which will remove the dulness of the lustre caused by too long immersion. After long use, the compound acids for a bright lustre may be employed in a certain measure for a dead-lustre bath. The mode of operation remains the same.

Dipping in Nitrate of Binoxide of Mercury.—This operation consists in plunging the cleansed articles for 1–2 seconds into a solution of $2\frac{1}{5}$ gal. water, $\frac{1}{3}$ oz. nitrate of binoxide of mercury, $\frac{2}{3}$ oz. nitric or sulphuric acid. When nitrate of binoxide of mercury is poured into the water, a thick cloud is formed, of a yellowish-white colour, which subsequently disappears. Stir the mixture before using it. The proportion of mercury salt above-named must be modified, according to the size of the pieces, and the nature of the alloy. Thus less mercury will be used for light pieces of jewellery which need a very thin deposit. On the other hand, more mercury is required for heavy objects, such as table ornaments, which should receive a thick deposit of gold or silver. The latter must come from the mercurial solution with a perfectly white and bright appearance, looking like silver, whilst the colour of the light articles is scarcely changed. After a perfect cleansing, the pieces will, after passing through a strong mercurial solution, be perfectly white and bright. But there will be a cloudy appearance, or various shades of colour, if the cleansing has not been properly done. The amalgamating bath becomes spent by use; it may be revived by the addition of a few drops of mercury nitrate; but it is better to prepare a fresh one. No intervals must be allowed between the various operations of cleansing. The dipping baths are ordinarily held in vessels of glass, stoneware, porcelain, or of any other material which resists the corrosion of acids. Common earthenware and that with a lead glaze must be carefully avoided. The dipping pots must be rather high, and be furnished with a cover, in order to prevent evaporation. Those with ground edges may be covered with a pane of glass. Wide open-mouthed earthen pans are very good for rinsing. A large hood, communicating with a chimney, and closed with a sliding glass sash, should contain the following apparatus for complete cleansing operations:—A furnace and separate pans for first dipping, old aquafortis, aquafortis and soot, compound acids for dead lustre, compound acids for bright lustre, solution of mercury nitrate, acids to dissolve gold from old pieces; acids to dissolve silver from old pieces; with two large pans for rinsing with a constant flow of water. If the draught of the chimney is not sufficient, a small fire may be kindled under the hood. A gas-burner is often sufficient. The pot of mercury nitrate, with two rinsing pans, may be placed near the plating bath.

Cleansing iron.—Cast iron is cleansed by being immersed for 2–3 hours in water containing 1 per cent. sulphuric acid; the metal is afterwards rinsed in cold water, and scoured with sharp sand and a fibre brush, or a coarse rag; then put again in the acid pickle, rinsed, and plunged into the plating bath. If more than 1 per cent. of sulphuric acid is added to the water, the length of the immersion must be shortened, otherwise the cast iron will be deeply corroded, and the carbon of the metal, which is insoluble in the pickle, will with great difficulty be removed by the friction of the sand. Cast iron does not gild or silver well, by a direct deposit of the precious metals. Copper or brass deposits are better, although far from perfect; but if cast iron is tinned, the coat is adherent, and will afterwards receive copper, brass, gold, or silver, if desired. If it is desired to keep cast iron cleansed for some time before plating it, it is necessary to preserve it in a liquor rendered alkaline by caustic lime, potash, or soda, or their carbonates; but caustic lime-water is the cheapest and most easy method, and cast iron which has remained in it for a few hours will not rust after a long exposure to a damp atmosphere.

The cleansing of wrought iron is effected in the same manner as cast iron, but it will bear a stronger pickle and a longer immersion, i.e. ordinary wrought iron covered with a film of black magnetic scale or of red rust. Whitened, filed, or polished iron must be treated like steel.

Cleansing Lead and Tin.—Tin, lead, and the alloys of these metals are much more difficult to cleanse than zinc. A rapid scouring with potash lye and a rubbing with a hard substance are the only means of effecting this. The objects are sometimes plunged into diluted hydrochloric acid; but the first operation is nearly always necessary. Notwithstanding the greatest care, the direct deposit of the precious metals is difficult, and does not adhere well. The results are much better if a coat of pure copper or brass is interposed between the low metal and the gold or silver.

Cleansing Silver.—Mechanical agents will not, like acids, act simultaneously on every part of the object, and it is impossible to entirely prevent the action of air, steam, gases, and acid fumes. Heat the object to a dull red heat upon a slow fire. If the silver is pure, it becomes covered with a thin bluish film; but if, as is nearly always the case, the silver is alloyed with a variable proportion of copper, the latter becomes oxidised, and covers the piece with a greyish-black coating. While the piece is still hot, plunge it into a boiling pickle of water and sulphuric acid, which dissolves the oxide. If the heat has been sufficiently protracted for oxidising all the copper on the surface, the object, when removed from the pickle, is of a perfectly dead white. It is greyish if the heating has been too short, and the operation must be repeated as many times as are needed for a perfect lustre. Or the silver may be placed in sheet-iron boxes filled with a mixture of powdered borax, lime, and charcoal dust. The borax dissolves the copper oxide as soon as formed. If the objects to be cleansed are hollow, it is necessary, before heating, to make a small hole which will allow of the escape of the air expanded by the fire. Without this precaution, the piece will burst open. When the piece is put into the pickle, the acid liquor enters through the hole, and takes the place of the air between the shells, and is difficult to remove. In order to prevent the spotting of the piece by this liquor, it is dipped for a few minutes into a very dilute solution of ammonia or of soda crystals, which prevents the action of the acid upon the silver. Then place the article between layers of dry and warm fir saw-dust, which will absorb the saline solution. Nitric, instead of sulphuric, acid, may be used for the pickle bath. In this case, the water must be distilled, and the acid free from chlorine or hydrochloric acid, otherwise the silverware will be covered with a bluish-white film of silver chloride. This method will not suit articles in which iron or zinc may be present. In such cases, employ alkalies, and polish afterwards with very fine sand or pumice, with the aid of a stiff and short brush, or with a scratch-brush alone. Perfectly cleansed silver may directly receive a metallic deposit which will have the same dead lustre as the object itself, but it is customary, before introducing the articles into the plating bath, to scratch-brush them.

Bright lustre for small articles.—Very small articles, which cannot be scratch-brushed, receive a bright lustre by mutual friction. The operation is generally performed with the hands. The articles to be brightened are introduced, together with boxwood saw-dust, bran, or sand, into a bag; the ends of the bag being gathered into the hands with the thumbs inwards, the bag is shaken to and fro. As this operation becomes very fatiguing, mechanical means may be employed to effect the shaking.

Cleansing Steel.—Polished articles of steel or iron must be first cleansed in a boiling solution of caustic lye, and rubbed with pumice dust, which scratches the polish slightly, and thus produces a better hold for the metals afterwards to be deposited. They are then rapidly passed through a bath composed of 1 qt. water, 12 oz. hydrochloric acid, 4 oz. sulphuric acid, rinsed in cold water, and plunged into the plating solution. Carefully avoid substituting nitric acid for the hydrochloric or sulphuric acid, of the above acid bath. Iron and steel may be well gilt, without an intermediary coat, in hot gilding baths. Silvering directly upon steel or iron is always imperfect and without adherence; it is therefore customary to interpose a coat of copper or brass, which renders the further operation of silver plating easy.

Cleansing Zinc.—Zinc is cleansed by being passed through a boiling solution of caustic lye, without remaining too long in it, because it may be corroded, and even dissolved; after rinsing, it is plunged for a few minutes into water containing 10–20 per cent. sulphuric acid, then rinsed in plenty of warm water, and, when necessary, brushed with a stiff brush and pumice dust, or scratch-brushed. This last operation is especially useful when parts have been united with tin solder, which becomes black and dull by the alkaline and acid baths. Another method is to dip the articles rapidly into a cold mixture of 100 parts sulphuric acid, 100 parts nitric acid, and 1 common salt, and quickly rinse in cold water perfectly free from copper salt, which will blacken the zinc. If, instead of quickly cleansing the zinc, it is allowed to remain a little longer in the mixture, it acquires a dead lustre which may be utilised for producing contrasts between the various parts of the same ornament. The dead lustre will become a bright one, if the object is quickly plunged in several times, and rinsed as often, in the same compound acids. It often happens that the lines of tin or lead solder are black after being dipped into the acid bath; it is then sufficient to scratch-brush before placing the object in the plating solution. Zinc may be slightly amalgamated with the solution of nitrate of binoxide of mercury; this increases the adherence of the deposits. It is often necessary, from some defect in cleansing, or in plating, which impairs the adherence of the deposits, to do the work over again. In such a case, remove the copper entirely by plunging the object into aquafortis and soot, until it appears black. Another dipping into the compound acids will render it perfectly clean and white, and ready to receive a new deposit.

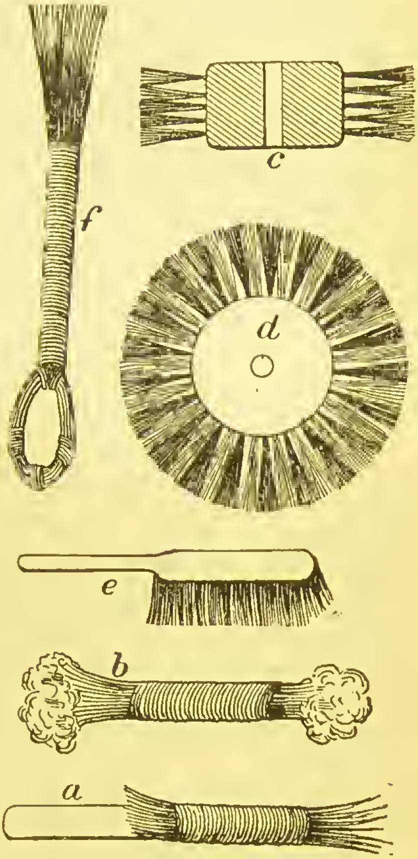
Scratch-brushing. — Scratch-brushing is to remove the dead lustre on an object by the frequently-repeated friction of the points of many stiff and straight metallic wires, called a scratch-brush or wire-brush. Its shape varies with the articles to be operated upon. A hand scratch-brush is made of numerous wires, stiff and straight, taken from a bundle or coil of large diameter, so that the wires have little tendency to curve. For delicate objects, scratch-brushes are made of spun glass, the fibres of which are very thin and elastic. For making a good hand scratch-brush, choose a bundle or coil of brass wire of the proper thickness, and wrap a good string tightly round it for about two-thirds of the intended length of the instrument, usually about 8 in. Then, with a cold chisel, cut the bundle of wire close to the string at one end, and at 2 in. from the other end of the string wrapping. Dip the end closed by the string into a neutral solution of zinc chloride, and plunge into melted tin, which solders all the wires, and prevents their separation, and injury to the hand of the operator. The tool is then fixed to a thin wooden handle which projects above the soldered end. Very small scratch-brushes are necessary for reaching small holes and corners. An old scratch-brush, the wires of which have been bent in every direction, and fixed to a long handle, is useful for rubbing the insides of certain pieces, such as vases. Scratch-brushing is seldom done dry; the tool and pieces must be constantly wetted with a stream of water, which carries away the impurities. Good metallic deposits are only polished by the friction of the scratch-brush; bad ones scale off from the defective adhesion. A large tub, with a board placed across it, on which to rest the pieces, may be used; and various solutions are employed to assist the brushing, such as water and vinegar, or sour wine, or solutions of cream of tartar or alum, when it is desired to brighten a gold deposit which is too dark; but generally a decoction of liquorice-root, horse-chestnut, or marsh mallow, all of which allow of a gentle rubbing with the scratch-brush, with the production of an abundant scum. Every 5 or 6 days the old liquid is carefully decanted, so as not to carry away the deposits at the bottom, as they always contain some of the precious metals, which are collected to be afterwards treated. For small objects and articles of jewellery, hold the scratch-brush as a writing pen, and the motion is imparted by the wrist only, the forearm resting on the edge of the tub. For larger articles of bronze, hold the fingers extended close to the fore part of the scratch-brush, so as to maintain the wires, and, with raised elbow, strike the piece repeatedly with a sliding motion at the same time. When a hollow is met which cannot be rubbed lengthways, a twisting motion is given to the tool. Circular wire-brushes, fixed on the spindle of a lathe, and the wires of which move all in the same direction, have been constructed for certain pieces of silversmith work, such as forks and spoons.

The brass wire used for the manufacture of hand or circular scratch-brushes is of various strengths. Thick wires are employed for bronzes, and thinner wires for lighter articles. The wires must be preserved stiff and straight. When a hand scratch-brush becomes too short, cut the twisted ends with a cold chisel, and a new portion of wire is uncovered by removing part of the string wrapping. To remove the twisted wire ends, rest the scratch-brush upon a lead block, and cut them with a sharp cold chisel, with one stroke of a hammer if possible. When they begin to curl, they are now and then beaten with a mallet of boxwood, upon a small block kept between the knees, so as not to produce a dead stroke. Scratch-brushes if kept too long in water become hard; when greasy, they are cleansed in caustic potash; oxide is removed by the compound acids. This last operation, and even dipping in aquafortis, is sometimes resorted to for diminishing the size of the wires and making them smoother. The circular brush is occasionally resorted to for diminishing the size of the wires, and making them smoother. The circular brush is occasionally reversed, in order to change the direction of the wires.

Fig. 102, *a b c d e f*, illustrates various forms of scratch-brush in common use. The circular pattern *c*, *d*, is, of course, employed in a lathe.

Lathe for Scratch-brush.—An ordinary lathe is used for scratch-brushing, upon the spindle of which is fixed a circular brush of brass wires. A wooden frame covers the wire brush; it is open in front; the top supports a small reservoir from which a slender jet of water runs upon the brush. A board receives the projected water, and lets it fall into a zinc pan resting on the bottom of the box.

Fig. 102.



Batteries. — The construction and manipulation of many kinds of battery have been fully described in the Third Series, but it is essential here to say something about the forms adapted to the needs of the electro plater. Although the dynamo machine, which is undoubtedly the best means of generating electricity, has now replaced batteries in large plating works, it is quite possible to turn out very good work with one or other of the many types of primary batteries.

Charging.—Taking as a standard an element 10 in. high and 6 in. diameter, half fill the stoneware pot with water;

add 7 oz. sulphuric acid at 66° B., and 1 oz. of amalgamating salt; or the zinc may be amalgamated with metallic mercury, after it has been cleansed in diluted sulphuric acid, by being dipped into mercury, or rubbed over with this metal by means of a scratch-brush of brass wire. Put the zinc cylinder into the stoneware pot; then introduce the cylinder of carbon into the porous cell; fill the empty space between the carbon and the sides of the cell with nitric acid at 36–40° B.; place the porous cell thus filled into the centre of the zinc cylinder. The surfaces of the two liquids should be level.

When several elements are to be connected, they are placed near each other, without touching, and the first carbon or graphite is left free for the attachment of the anode. The ribbon or band of the first zinc is pinched between the jaws of the brass binding screw, and the carbon of the second element, and so forth, until the last zinc is ready to be connected with the object to be electro-plated.

Bringing into Action.—Batteries will furnish electricity when the circuit is closed, that is to say, when the conducting wires starting, one from the carbon, and the other from the zinc, are put into communication, whether by direct contact or through the medium of a conducting liquid. It sometimes happens that batteries, which appear to be in good order, do not work. This is generally due to some foreign substance preventing the conductibility at the points of contact, or to the copper band of one zinc resting upon another zinc. Before using a battery, try if the current escapes well from both extremities. For this purpose present the point of the negative wire to the carbon of the other end, and a spark should immediately ensue. The same experiment being made with the positive wire, against the last zinc, another spark should be produced; or it is still more easy to have the two ends of the wires made to rest at a short distance from each other upon a piece of carbon, or upon a file, and then rubbing with one wire while the other remains in contact. Numerous sparks will immediately appear. When one element of a battery is wrongly put up, discover the defect by successively presenting the end of one of the wires to the carbon of each element, and that which does not produce any spark belongs to the defective element. Too much porosity in the cells is another cause of stoppage in the current, because the solution of zinc which penetrates deposits upon the carbon a whitish coat preventing further action. Change the cell and scrape off the coat entirely from the carbon. This generally takes place when the battery has been working several days without the addition of fresh liquor, or when there is too much acid. The battery will also cease working from too great an accumulation of zinc sulphate, which, not having sufficient water to remain in solution, crystallises upon the zinc, and prevents any further action. Remove the acid solution, substitute a fresh one, and clean the zinc. Laminated zinc is preferable to that cast in a mould, because the latter is not so homogeneous, and is more rapidly corroded, and even perforated.

Keeping in Order.—Every 24 hours, or oftener, the losses of batteries must be made good by adding, without taking the elements apart, about two teaspoonfuls of amalgamating salt, and as much of sulphuric acid, to the liquor of the zinc plates, and stirring with a glass rod. Nitric acid, to replace that evaporated, is put into the porous cell. This manner of operating may be sufficient for 5 or 6 days; but after this lapse of time, all the old liquors must be removed, and fresh ones added. Although amalgamated zinc is scarcely corroded, even in a very acid solution, when the two poles are not in connection by direct contact, or through a conducting liquid, it is preferable to take the batteries apart every evening, in the following manner:—All the binding screws are let loose, and cleaned; the cylinders of carbon are removed, and, without washing, deposited in a vessel especially for their use; the porous cells are removed, and their acid is poured into a special vessel. The cells are not washed; the zincs are removed from the acid liquor, and placed in an inclined position upon the edges of the stoneware pots; the batteries are made ready to work by a converse manipulation.

Batteries must be kept in a place where the temperature does not greatly vary. A frost arrests their action, and great heat increases it too much. A good place for them is a box, and they are put at such a height that they may easily be manipulated. This box should have means of ventilation, in such a way that the air coming in at the lower part will escape at the top through a flue, and carry away with it the acid fumes constantly disengaged. It is best to keep the batteries in a room different from that where the baths and the metals are to be operated upon, as these are easily injured by acid vapours. The galvanic current may be conducted into the workroom by wires passing through holes in the wall, and covered with gutta-percha.

Various Kinds of Deposit.—An intense current, for brass and hard deposits will be obtained by joining alternately the zinc of one element to the copper or carbon of the next. For silver plating, a smooth and not too hard deposit is desired, the current should be feeble in intensity, but considerable in quantity, and may be obtained by connecting together all the zincs on the one side, and all the coppers or carbons on the other.

Porous Cells.—The porous cells are absolutely necessary in batteries working with two exciting solutions. But the trouble arising from the clogging of the pores of the cell, and from the difficulty of preventing the diffusion between the two liquids of the porous cell and of the jar, the specific gravity of which is constantly varying, makes it desirable that the cell should be dispensed with in batteries worked with but one exciting fluid.

Bunsen's.—Each element is composed of a glass vessel which is half filled with nitric acid at 36°–40° B., and which receives a hollow cylinder of pulverised coke, moulded and cemented at a high temperature, by sugar, gum, or tar. At the upper part of this cylinder, where it does not dip into the acid, a copper collar is fixed, which may be tightened at will by means of a screw. A copper band or ribbon is fixed to the collar, and may be connected with the zinc of another element. A porous porcelain cell is placed inside the coke cylinder, and contains a diluted solution of sulphuric acid, 1 part acid and 9 water, into which is put a bar or cylinder of zinc strongly amalgamated, or covered with mercury. When a battery of several elements is to be formed, the coke of the first element is connected with the zinc of the second, and so on, and the apparatus is completed, at one end, by coke communicating with the anode, and at the other, by a zinc connected with the cathode, or object to be electroplated. In this apparatus the surface of the carbon is much greater than that of the zinc; this is a wrong disposition, since, generally, the intensity of the current is in direct ratio with the surface of the zinc corroded, provided that this surface be opposite and parallel to that of the carbon.

Bunsen's modified by Archereau.—This battery is preferred by gold and silver platers. Each element is composed of an exterior vessel or pot, most generally of stoneware; a cylinder of zinc, covered with mercury, provided with a binding screw, or with a copper band, whether for a single element, or for the end of a combination of elements in a battery, or to connect the zinc with the carbon of another element. A porous cell of earthenware pipe or porcelain. A cylinder of graphite, made from the residue found in old gas retorts. The graphite is bound by a copper band fixed to it by means of a wire of the same metal, all the binding being afterwards covered with a thick varnish to protect it from the acid fumes of the battery; notwithstanding the varnish, the acid may rise by capillary attraction and corrode the copper band between the carbon and the wire; therefore binding screws of various shapes and sizes should be used to connect the carbon or zinc by means of ribbons or wires. Use conducting wires of pure copper, covered with cotton, silk, rubber, or gutta-percha, and presenting the metal at their extremities in order to effect the connections.

Callaud.—The Callaud battery is a modification of that of Daniell, doing away with the porous cell. A jar is filled with water acidulated with sulphuric acid, only for starting the solution of the zinc, as the sulphuric acid will be furnished afterwards by the copper sulphate. The zinc and copper plates are both placed horizontally in the jar; the zinc in the upper part, and the copper lying on the bottom. To start this battery, throw into the jar a few crystals of copper sulphate. These go to the bottom, dissolve, and form a saturated solution around the negative plate of copper. The electrode or conducting wire from the copper plate may be made to pass through a glass tube reaching down to the bottom of the jar, and large enough to contain a supply of crystals of copper sulphate necessary to keep a saturated solution in the lower part of the cell. This avoids disturbing the upper part of the liquid in which the zinc dips, and its mixture with the solution of copper sulphate. The deposits from the zinc and other impurities are prevented from falling upon the copper plate, and thus interfering with the current, by covering the copper plate with a layer of clean quartz sand, which serves also as an obstacle to the effusion upward of the copper sulphate, because the interstices between the grains act as a series of narrow tubes, but the force of the current diminishes by reason of the increased resistance.

Daniell's.—This battery develops a constant and lasting current, but is wanting in intensity. It is especially adapted to slow deposits, which must be thick and of uniform texture. A great advantage of this battery is, that it will work without acids, and therefore without the production of gases or smell, and can be used in a private apartment without inconvenience. The vase for the battery is a flat vessel of pure copper, which is half filled with a saturated solution of copper sulphate, into which is placed a bag of canvas or a cell of porous porcelain or earthenware, which causes the solution of copper sulphate to rise to about 1 in. from the top of the copper vessel. The bag or cell is filled with a saturated solution of common salt, in which a well-cleansed zinc-plate is placed. It is necessary that the levels of the two solutions should be nearly the same. If there is any difference, the solution of sodium chloride should be slightly above the other, because if the solution of copper sulphate passes into the porous cell, the zinc is immediately corroded, and blackened, and the battery may cease to work. When one of Daniell's elements only is used, which seldom happens, on account of the feeble intensity of the current, the conducting wire which supports the article to be galvanised is connected with the zinc plate by a binding-screw of brass, and the other wire supporting the anode is connected with the copper of the exterior vase. The solution of copper sulphate must be kept constantly saturated with crystals of this salt, enclosed in a bag of linen or hair cloth. A similar process may be employed to keep the solution of common salt in a state of saturation. A battery thus arranged may be kept in operation for 3-4 weeks. When this battery is working, the copper of the decomposed sulphate is deposited upon the copper of the vessel, which thus increases in weight and in value. The zinc is slowly dissolved in the solution of common salt, and forms a double chloride of sodium and zinc. When a number of the elements of a Daniell's battery are to be joined together, the zinc of the first element is connected with the copper of the second by means of a well-cleansed metallic ribbon, then the zinc of the second with the copper of the third, and so on, until the whole apparatus presents at one end a copper vase, and at the other a zinc plate, unconnected. A metallic wire connects the anode with the copper end, and a similar wire is bound to the zinc end, and supports the object to be plated.

Another battery used by the electro-gilders of watch parts and by telegraphers, is composed of a cylindrical vase of stoneware, glass, or porcelain; a cylinder of zinc to which is soldered a ribbon of pure copper; a porous clay cell, and a glass balloon with a short neck, and filled with crystals of copper sulphate. It is closed with a cork perforated with two holes, or having two notches cut along its sides. The rolled zinc plate is put into the stoneware pot, and the porous cell inside the zinc. The copper ribbon of the zinc of the first element dips on to the bottom of the cell of the next element, in such a manner that, when several elements are connected together, there is at one end the ribbon of a zinc plate, and at the other end a copper ribbon put into the cell. Then the porous cell and the stoneware pot are filled to the same level with water. The balloon containing the crystallised copper sulphate receives as much water as it can hold, and the notched cork being put in place, the balloon is quickly inverted with its neck in the water of the porous cell. The battery is ready to work 24 hours after. The ribbon of the zinc end is connected with the objects to be plated, and that of the other cell end, with the soluble anode. The copper sulphate contained in the balloon is dissolved in the water around it, and as this solution is denser than water it falls into the porous cells through one of the notches of the cork, while an equal quantity of purer and lighter water ascends through the other notch, and so on, producing a circuit of denser liquor falling by one notch, and of lighter liquor rising by the other. The solution of copper sulphate is decomposed in the porous cell; the sulphuric acid passes through the cell by outward pressure and acts upon the zinc, and at the same time the copper becomes deposited upon the copper ribbon connected with the zinc of the former element. In order that this battery may work regularly for 6–7 months, it is sufficient to replace the evaporated water. The balloon ought to contain at least 2 lb. of copper sulphate, and the zinc to be about 7 in. high, and 4–4½ in. diameter. The zinc may be amalgamated, in which case the action is a little slow at the start, but more regular afterwards. The copper ribbon receives all the metal of the decomposed sulphate, and it sometimes happens that part of the copper becomes deposited upon the porous cell, which must then be cleaned in aquafortis. When all the copper sulphate is used up, the balloons are filled with a fresh quantity of crystals and new copper ribbons are inserted to take the place of those rendered too voluminous. If it be desired to start the battery with a balloon immediately, add a small quantity of sulphuric acid, or of common salt, to the water in which the zinc is placed.

For the requirements of a small plating shop the Daniell cell is perhaps the best. Two cells made as follows will do very well for small work: Procure two stoneware jars large enough to hold about 2 gal. each; turn up two pieces of light sheet copper, so as to form cylinders, a little smaller than the internal diameter and about the height of the jars. In the centre of each of these cylinders stand a porous cell (the tops of these cells to the depth of about 1 in. should be soaked in hot paraffin wax to prevent the creeping action of the salts in solution). In each porous cell place a cast zinc rod about 1 in. diameter; lastly, solder terminals to each zinc and copper. The charge for this battery consists of a saturated solution of copper sulphate, slightly acidulated with sulphuric acid, in outer stoneware cell, and sulphuric acid 1 part, water 12 to 15 parts, in porous cell. If the zincs are kept well amalgamated, the sulphate solution saturated, and both solutions at the same level, this battery will continue to give a steady current for a considerable time. All wires used for connections should be large, not less than 14 B.W.G., so that the external resistance is kept as low as possible.

Grove's.—This battery has a platinum foil which plunges into the nitric acid, and replaces the prism of carbon. This foil is supported by a small brass stand, fixed itself to a round band resting upon a rim on top of the exterior vase. A binding screw is soldered to the stand when connection is to be made with the copper ribbon of the preceding zinc. The several elements of batteries are united together in the manner already mentioned, the zinc to the platinum of the next element, and so on. The disadvantage of this battery is its great cost, due to the platinum employed; it has been proposed to substitute aluminium, but still the battery is an expensive one.

Grenet's.—A solution of 100 parts water, 10 of potash bichromate, and 10 of sulphuric acid in the porous cell, replaces the nitric acid employed by Grove and Bunsen. This battery does not emit acid fumes, but the carbon is rapidly incrusted with chromium oxide, which arrests the galvanic current.

Marié-Davy.—Slightly damp mercury sulphate replaces the nitric acid in the porous cell. The working expenses of this battery are very high, and it is used only in the telegraphic service, where the Daniell battery with balloons is not preferred.

Smee's.—This battery is very simple in construction. It is composed of a thick wooden frame open at the top, with three internal parallel grooves which run the height of the two opposite sides. The middle groove receives a movable plate of silver, platinum, gold, or copper which has been strongly gilt, silvered, or platinised; its surfaces must be rough or with a dead lustre. Two plates of strongly amalgamated zinc are run down the other two grooves. The plates of zinc must be near to, but not in contact with, the central one, and are connected by a wire or metallic band. The positive wire starts from the middle plate, and the negative from the zinc, and the whole apparatus is immersed in a solution containing common salt or $\frac{1}{10}$ of sulphuric acid. Several elements may be united together by connecting the zinc of the first with the middle plate of the second. Or the cell may be made of gutta-percha, with a plate of carbon to replace the plate of silver, or of platinised copper. The two other grooves receive two plates of amalgamated zinc with one of the upper corners cut away. A double binding screw, for the positive wire, is fixed upon the plate of carbon where the two zinc corners have been cut off, and another large binding screw unites the two zinc plates, and carries the negative wire. Fill the cell with water saturated with common salt, or acidulated with $\frac{1}{10}$ of sulphuric acid.

Watt's.—In a stoneware jar holding about 4 gal., place a cylinder of thin sheet copper, dipping into water acidulated with 2 lb. sulphuric acid and 1 oz. nitric acid. A solid zinc cylinder is put into the porous cell, which is filled with a concentrated solution of common salt, to which a few drops of hydrochloric acid have been added.

Vats, &c.—For small work, earthenware pans, white glazed inside, make very good vats. The size depends to a great extent on the class of work likely to be undertaken, but one holding 4–5 gal. is a very useful size. If possible, the pan should be about the same in depth as it is in diameter. A large bell-glass or fish globe serves well.

Three pieces of $\frac{3}{8}$ in. brass or copper rod should be procured, long enough to reach across the vat. These are termed slinging rods, from which the anodes and articles to be plated are hung. Suitable suspending rods for the articles are made of small bent glass tubing.

The water used must be quite pure, in other words distilled water alone is suitable.

Amalgamating Salt.—This is a mercury salt with three acids, and is composed of the sulphate, nitrate, and bichloride of this metal. It is liquid, more or less coloured, very dense, and gives in water a yellow precipitate, which is dissolved by an excess of acid. It produces a violet stain on the skin, and amalgamates copper and its alloys thoroughly and rapidly. It is used for amalgamating the zincs of batteries, and dispenses with the metallic mercury; it is more easily applied, and prevents much trouble in gilding works. It is prepared by boiling the nitrate of binoxide of mercury upon an excess of a powder composed of equal parts of bisulphate and bichloride of mercury; the liquor only, remaining after cooling, is used.

Antimony Deposits.—(*a*) This has all the brightness of polished cast iron. Its dead lustre is a slate grey, and it may be easily scratch-brushed and polished; it resembles black platinum, and may take its place in many cases. Boil for an hour, in a porcelain dish or enamelled cast iron vessel;—$2\frac{1}{5}$ gal. water, 70 oz. soda carbonate, $17\frac{1}{2}$ oz. finely-powdered antimony sulphide. Filter the boiling solution through paper or fine cloth; by cooling it deposits a reddish-yellow powder of antimony oxysulphide. Boil this powder again in the same liquor, and the new solution is the antimony bath. It is necessary to use the bath constantly boiling. For the anode, use either a plate of antimony or a platinum wire.

(*b*) Copper may also be covered with a layer of antimony by the following process:—Dissolve antimony chloride in alcohol, and add hydrochloric acid until the mixture becomes clear; clean the copper well, and leave it in the bath for $\frac{3}{4}$ hour. The effect of the alcohol is thus explained: it moderates the precipitation of one metal from its solution by another metal, and causes the precipitate to fall in an extremely divided state; when alcohol is used alone, without water, the coating of copper thrown down is reduced to the last degree of tenuity. It is recommended that when the work is finished it should be well washed, first in water, and afterwards several times successively with a solution of soda carbonate, and with weak hydrochloric acid, and finally carefully dried in a warm place.

Bismuth Deposits. — Bertrand has succeeded in producing a galvanic deposit of bismuth on the surfaces of other metals. He uses a double chloride of bismuth and ammonia. The operation is performed cold, with a solution containing 25–35 gr. of chloride per litre. A single Bunsen pile should be used. On coming out, the objects are coated with a dark-looking slime, beneath which the sheen of the bismuth may be detected. The latter adheres very closely to the subjacent metal, and takes a fine polish, the colour being intermediate betwixt antimony and old silver.

Brass Deposits.—All the manufactures of bronze composition made of zinc or cheap alloys, have a brass deposit placed on before the bronze lustre is given, as the bronzing operation is more easy and satisfactory upon brass deposits. The preliminary and finishing operations and the disposition of the baths are the same for brass as for copper deposits. Heat is employed for brass deposits by those who electroplate coils of iron or zinc wire with this alloy. The proper temperature varies from 130° to 140° F., and the coils of wire dip only one-half or two-thirds of their diameter into the bath. The bath is put into an oblong open iron boiler heated by fire, steam, or hot water. The inside is lined with brass sheets connected with the positive pole of a battery. A stout copper or brass rod, in the direction of the length of the boiler, rests upon the edges, and the contact of the two metals is prevented by pieces of rubber tubing. The rod is connected with the negative pole by a binding screw. Remove the binding wire from the coils, and loosen the wires, bending the ends together into a loop. Dip the wire in a pickle of dilute sulphuric acid, and hang it on a strong round peg held in the wall, so that the coil may be made to rotate easily. After a scrubbing with wet, sharp sand and a hard brush, give the coil a primary deposit of pure copper. It is then suspended from the horizontal rod over the brass bath, where only a part of the coil at a time dips into the solution and receives the deposit; the coil must be turned now and then $\frac{1}{2}$ or $\frac{1}{4}$ of its circumference: by dipping the coil entirely into the liquid, the operation is not so successful. The wires are washed, dried in sawdust, and then in a stove, and lastly passed through a draw-plate, to give them the fine polish of true brass wire. Copper and brass wires are also covered with brass electro-deposits, in order to give them various shades.

Solutions for Baths.—(*a*) The ordinary potassium cyanide is often preferred to the pure article, on account of its lower price; but the real value and dissolving property of ordinary cyanide are very variable. The following is a general method by which a bath of brass may be prepared with any kind of cyanide. Dissolve together, in 2 gal. water, 8 oz. copper sulphate, and 8–10 oz. zinc sulphate. (*b*) 4 oz. copper acetate, with 4–5 oz. fused zinc protochloride; and add a solution of 30 oz. soda carbonate, which produces a precipitate of copper and zinc carbonates; allow this to settle; then decant the supernatant liquor, and replace it by fresh water two or three times, after as many settlings. Then pour on 2 gal. of water containing, in solution, 30 oz. soda carbonate, and 15 oz. soda bisulphite; while stirring with a glass or wooden rod, add ordinary potassium cyanide until the liquor is perfectly clear, or until nothing but the greyish-black iron, found in the cyanide, or the brown-red iron oxide in the zinc sulphate, remains in suspension. An additional quantity of about 1 oz. of ordinary cyanide improves the conducting power of the liquor.

(*c*) Cold, for all Metals.—Copper and zinc carbonates, recently prepared, each 4 oz.; soda carbonate, in crystals, soda bisulphite, and potassium cyanide, pure, each 8 oz.; and $\frac{1}{10}$ oz. white arsenic; water, about 2 gal. This bath is prepared as follows:—Dissolve in 3 pints water, 5 oz. copper sulphate, and 5 oz. crystallised zinc sulphate, and add a solution of 14 oz. soda carbonate in 1 qt. water. A greenish precipitate of mixed copper and zinc carbonates is formed: stir well, and allow to deposit for several hours. The supernatant liquid, holding the useless soda sulphate, is thrown away, and replaced by nearly 2 gal. water, in which are dissolved the bisulphite and carbonate. Dissolve together in the remaining warm water the potassium cyanide and the arsenious acid, and pour this liquor into the former one, which is rapidly decolourised, and forms the brass bath. Filter if necessary. Arsenious acid causes the deposit to be bright, but if in too great a proportion may give a white or steel-grey colour to the metal. This inconvenience is slight, as the yellow colour soon predominates. The arsenious acid may be replaced by soluble arsenites of potash, soda, or ammonia, but the proportions must be doubled. The baths for cold plating are generally placed in wooden tanks lined inside with gutta-percha, which resists their action for a long time. The sides of the tank are also lined with one or more brass sheets joined together, connected with the last carbon or copper of the same battery, the intensity of which is regulated by the surface of the articles to be plated. The articles are suspended by copper or brass hooks to stout rods of the same metal, all connected with the last zinc of the battery.

(*d*) For Iron and Tin.—Dissolve together in 14 pints pure water:—7 oz. soda bisulphite, 17 oz. potassium cyanide No. 2, 34 oz. soda carbonate. To this solution add the following, made in $3\frac{1}{2}$ pints water:—$4\frac{1}{2}$ oz. copper acetate, $3\frac{1}{2}$ oz. neutral zinc protochloride. The two liquors become colourless when mixed. Ammonia must not be used for brass plating baths for iron, especially for solutions worked in the cold.

(*e*) A colour resembling brass is given to small articles of iron or steel by a long stirring in a suspended tub, containing 1 qt. water, and of copper sulphate and tin protochloride crystallised, about $\frac{1}{5}$ oz. each. The shades are modified by varying the proportions of the two salts.

(*f*) For Lead and Pewter.—Lead and pewter should be cleansed in a solution of about 4 oz. nitric acid to 1 gal.

water, in which they remain for ½ hour. Pewter is more easily coated with brass than lead, but the same bath may be used for either. They are then rinsed, scoured with sand, and rinsed again. A good battery power and a large surface of anode are necessary, especially at the beginning of the deposit. The proper temperature of the bath for brassing lead, pewter, and tin is about 90° F. Stirring articles in a brass bath has a tendency to cause the deposition of copper alone.

(*g*) For Zinc.—Pure water, 4½ gal.; soda bisulphite, 24½ oz.; potassium cyanide, No. 2, 35 oz. Add the following solution:—Water, 9 pints; copper acetate and zinc protochloride, each 12½ oz.; ammonia, 14 oz. The filtered bath is colourless, and gives, under the action of the battery, a brass deposit of a very fine shade, varying from red to green, by increasing the proportion of copper, or that of zinc. The anode is of brass.

Arrangement of Bath.—In the disposition of the baths for brass plating, it is always necessary to have all the articles suspended at about equal distances from the anodes; the bath may be subdivided by several anodes forming partitions, so that each loaded rod is between two anodes, or smaller separate baths may be employed. The anodes should be removed when the bath is not at work. In order that the brass plating of zinc and copper may be lasting, the deposit must not be too thin, and must be scratch-brushed, rinsed in water rendered slightly alkaline by quicklime, and thoroughly dried in a stove. But generally the articles are brass plated by remaining in the bath for 10–25 minutes. Cast and wrought iron, lead and its alloys, require brass solutions richer in the metals than when depositing upon zinc or its alloys. The battery power should also be greater.

Correcting Bath.—The losses of the solution are to be repaired by additions of copper and zinc salts, and arsenious acid dissolved in potassium cyanide. The operator will determine the needed substances from the rapidity of the deposit, its colour, and so on. If the deposit is too slow, try whether the bath will absorb the salts of copper and zinc, without the addition of cyanide. If the coat of brass has an earthy and ochreous appearance, and especially if the liquor is blue or green, add potassium cyanide until perfect decolourisation takes place. If the deposit is dull and unequal, add a small quantity of arsenious acid dissolved in cyanide. If the deposit is too red, add the salt of zinc, alone, or dissolved in cyanide. If the deposit is too white, or of a greenish-white colour, add the salt of copper, alone, or dissolved in cyanide. When the bath after long use has become overloaded with salts, the specific gravity is too great for the easy passage of the electric current, the liquor must be diluted with water until it works satisfactorily. The specific gravity of a brass bath may vary from 5° to 12° B. The pieces, before brass plating, must be perfectly cleansed in the same manner as zinc or iron; if the brass deposit is irregular, remove the objects from the bath, rinse, scratch-brush, and put again into the bath until the colour and the thickness of the deposit are satisfactory. Scratch-brush again, and, if necessary, rinse in hot water, dry in warm sawdust of white wood, and put in the stove-room. The last three operations are indispensable for hollow pieces.

Colour of Deposit.—The difficulty in brass plating, especially with small baths, is in keeping uniform the colour of the deposit, as the galvanic current, having simultaneously to decompose two salts each offering a different resistance, must, according to its intensity, vary the composition and the colour of the deposited alloy. It will be found that a feeble current principally decomposes the copper salt, and results in a red deposit; whilst too great intensity in the current decomposes the solution of zinc too rapidly, and the deposit is a white or bluish-white alloy. This is the case more especially with newly-prepared baths, and is an indication of irregularity in the conducting power of the bath, which, however, becomes more regular after being used for some time. The inconvenience of a red deposit may be remedied by increasing the number of the elements of the battery, or employing stronger acids, or decreasing the number and the surfaces of the objects to be plated; the other inconvenience of white deposits will disappear by diminishing the number of elements, or by increasing the surfaces to be covered. The deposit may also be modified by substituting for the brass anode, either a sheet of pure copper, or one of zinc, or by simply hooking one of these sheets to the brass anode. A bath of pure copper will be transformed into one of brass by the use of a zinc anode; and a bath of brass will become one of copper by the aid of a copper anode.

Bronzing.—Bronzing is the process of giving a bronze-like or antique metallic appearance to surfaces.

Antique Bronze.—Dissolve in 20 parts by weight of ordinary strong vinegar 3 parts of carbonate or hydrochlorate of ammonia, and 1 each of common salt, cream of tartar, and copper acetate, and add some water. When an intimate mixture has been obtained, smear the object with it, and let it dry at the ordinary temperature for nearly 48 hours. After that time the object is entirely covered with verdigris of various tinges. Then brush the whole, and especially the reliefs, with the waxed brush. If necessary, the raised parts are set off with chrome yellow, or other suitable colours. Light touches with ammonia give a blue shade to the green portions, and ammonia carbonate deepens the colour of the parts on which it is laid.

Black Bronze.—A steel bronze is obtained by wetting the articles with a dilute solution of platinum chloride, and slightly heating. This bronze will sometimes scale off by friction. It may also be obtained by dipping the cleansed copper into a weak warm solution of antimony chloride in hydrochloric acid. But sometimes the colour is violet instead of black.

Brass.—(*a*) Cleaned up brasswork, if left in damp sand, acquires a fine brown colour, which, when polished with a dry brush, remains permanent and requires little cleaning. A green and light coating of verdigris on the surface of the brass may be made by means of dilute acids, allowed to dry spontaneously. The processes are, however, slow, and quicker means have to be adopted. Before bronzing, the brass is annealed, pickled in old or dilute nitric acid till the scales can be removed from the surface, scoured with sand and water, and dried. Bronzing is then performed according to the colour desired. A steel-grey colour is deposited on brass from a dilute boiling solution of arsenic chloride; and a blue by careful treatment with strong soda hydrosulphate. The Japanese are said to bronze their brass by boiling it in a solution of copper sulphate, alum, and verdigris. Success in bronzing greatly depends on the temperature of the brass or of the solution, the proportions of the metals used in forming the alloy, and the quality of the materials; the moment at which to withdraw the goods and the drying require attention.

(*b*) The articles, which must be free from grease, and polished, are first immersed, for ½ minute, in a cold solution of 10 grm. potassium permanganate, 50 grm. iron sulphate (ferrous), and 5 grm. hydrochloric acid in 1 litre of water. They are then washed off and dried in fine, soft sawdust.

(*c*) If the colour has become too dark, or if a more reddish-brown colour is required, the objects are immersed, immediately after they have been taken out of the liquid, for about 1 minute in a warm (140° F.) solution of 10 grm. chromic acid, 10 grm. chloric acid, 10 grm. potassium permanganate, and 50 grm. iron sulphate in 1 litre of water, and treated as above. By using the second liquid alone, a brighter, dark-yellow, or red-brown colour is produced. The objects may afterwards be heated in a drying oven, whereby the colour is considerably improved.

Cardboard.—First make a sieve by glueing a piece of fine muslin or butter-cloth all round a frame, made of deal, 4 in. square, 1½ in. deep, to put the bronze powder in, next make some glue-water rather thinner than cream, and strain through a fine cloth or muslin; put the glue-water in a basin, and place it where the lid should be on the tea-kettle; place the kettle on the fire to heat the glue (hotter the better). Have your cardboard quite flat; put on the glue-water very quickly and evenly with a 2 in. flat camel-hair brush; go over the card with the sieve in your left-hand, tapping the sieve gently with the fingers of your right-hand, it will be ready for dusting in an hour's time; use a piece of card about 14 in. by 12 in. for a trial.

Copper.—Bronzing copper by the well-known method of heating it over a fire is a tedious and not altogether satisfactory process. It involves the exercise of some skill, and a considerable amount of labour must be expended in the preliminary processes of cleansing and polishing; and very often the whole operation has to be performed over again, owing to some accidental blemish imparted to the surface of the article in some subsequent process—*e.g.*, brazing or soldering. The polishing powders principally employed are crocus and plumbago, the latter giving a deeper and more permanent colour to the finished article than the former, while shades between can be obtained by mixtures of the two powders. There are several secret processes employed by the principal workers in the art, the substances used in which are known, but the exact methods are undescribed. Potassium sulphide and ammonia hydrosulphate are both capable of imparting to the surface of clean copper an appearance of antique bronze. The solution is brushed on carefully and allowed to dry, the metal being previously heated to about 70° F. A solution of verdigris and sal-ammoniac in vinegar, diluted with water, boiled and filtered, is used as a sort of pickling bath for brass and copper articles it is desired to bronze. The bath must be kept at the boiling point, and care must be taken that the articles are removed as soon as the desired effect is produced. A bronze, said to be used by the Chinese, is made, like the last, of sal-ammoniac and verdigris, with the addition of alum and vermilion (i.e., the pure article prepared from mercury and sublimed sulphur). These ingredients, when reduced to a fine powder and made into a paste with vinegar, are spread over the surface of the article to be bronzed, which is then placed in an oven, where it heats slowly but uniformly. When thoroughly warm, the paste is carefully washed off in hot water, and the article is rapidly dried, with the assistance of hot box sawdust, if of special value. If the bronzing is not of a sufficiently deep tone, the process is repeated immediately after the washing. The common bronzing solution for metallic statuettes is made by dissolving about 1 part potassium binoxalate and 3 of sal-ammoniac in strong vinegar, or preferably in a vinegar made by adding pure acetic acid to distilled water. The articles to be bronzed are placed in a warm but moist chamber, and are repeatedly painted over with the solution, a soft brush or mop being used for the purpose. In the majority of the methods employed, the actual proportions of the ingredients are not stated, or when stated are not to be relied upon; in every case a trial should be made on clean pieces of copper, and repeated at least once. As a rule, it will be found that the sal-ammoniac must be in excess of the other salts.

Iron.—(*a*) To 1 pint methylated finish add 4 oz. shellac and ½ oz. benzoin; put the bottle in a warm place, shaking it occasionally. When the gum is dissolved, let it stand in a cool place 2–3 days to settle, then gently pour off the clear mixture into another bottle, cork it well, and keep it for finest work. The sediment left in the first bottle, by adding a sufficient quantity of spirit to make it workable, will do for the first coat or coarser work when strained through a fine cloth. Next get ½ lb. finely ground bronze green—the shade may be varied by using a little lamp-black, red ochre, or yellow ochre; let the iron be clean and smooth, then take as much varnish as may be required, and add the green colour in sufficient quantity; slightly warm the article to be bronzed, and with a soft brush lay on it a thin coat. When that is dry, if necessary lay another coat on, and repeat until well covered. Take a small quantity of the varnish and touch the prominent parts with it; before it is dry, with a dry pencil lay on a small quantity of gold powder and then varnish the whole.

(*b*) Give a superficial coating of copper by electrolysis, which can then easily be bronzed by means of an application of weak ammonia, which may be allowed to dry off, and the castings then be brushed in the prominent portions. A layer of good clear spirit-varnish greatly increases the durability of this bronzing.

(*c*) The finished coatings may be brushed over with a mixture of hard white varnish, and finely-ground bronze green, of an oily consistency. The castings must be slightly warmed, and be quite smooth and clean. When the first coat is dry, which soon takes place, another can be applied if required, taking care to lay on thinly each time, and to get body by repeated applications. This being satisfactorily coloured, a small quantity of gold bronze power is taken up with a dry camel-hair pencil, and the prominent edges of the work are lightly touched with another brush dipped in clear varnish; while still tacky, the bronze powder is laid on with the dry brush. Again the work is allowed to dry thoroughly, when a final thin coating of the best hard varnish is given all over.

(*d*) The iron to be treated is properly cleaned and dipped in a crucible of melted bronze, on which floats a covering of melted borax; it is stirred in this until it acquires the temperature of the molten mass, and becomes covered; it is then taken out and placed to cool in a hearth. Larger pieces of iron must be heated first, that they may not reduce the temperature of the molten metal too much.

Medals.—This operation is to give to new metallic objects the appearance of old ones, by imitating the characteristic appearance imparted by age and atmospheric influences to the metals or metallic compounds, and especially to copper and its alloys.

(*a*) The most simple bronze is obtained by applying upon the cleansed object a thin paste made of water with equal parts of plumbago and iron peroxide, with a certain proportion of clay. Then heat the whole, and when the object is quite cold, brush in every direction for a long time with a middling stiff brush, which is frequently rubbed upon a block of yellow wax, and afterwards upon the mixture of plumbago and iron peroxide. This process gives a very bright red bronze, suitable for medals kept in a show case.

(*b*) This bronze may also be produced by dipping the article into a mixture of equal parts of perchloride and nitrate of sesquioxide of iron, and heating until these salts are quite dry. Then rub with the waxed brush as described.

(*c*) Cleanse the article, and cover it with ammonia hydrosulphate, which allow to dry, then brush with iron peroxide and plumbago, and afterwards with the waxed brush. If the piece impregnated with ammonia hydrosulphate is gently heated a black bronze is obtained, which being uncovered at certain places produces a good effect.

Plaster Ornaments. — (*a*) Obtain a bottle of Japan gold size, a rather broad camel-hair brush, and the desired quantity and shade of bronze powder. Then, with an ordinary pig-bristle brush, give the article a coat of the Japan size to fill up the pores. When quite dry, give another coat. Let it stand until it becomes slightly sticky (not too wet or else it will drown the bronze). Then dip your camel-hair brush into the bronze, and carefully brush it over the article until completely covered, taking care to hold the work over a sheet of paper to save all the surplus bronze. The bronze is about 2*s.* 6*d.* to 3*s.* an oz., but ¼ oz. goes a very great way. Some, after the above operation, cover over with mastic varnish. Of course, if they are likely to be handled, the varnish will preserve them.

(*b*) Prepare a soap from linseed oil boiled with caustic soda lye, to which add a solution of common salt, and concentrate it by boiling till it becomes somewhat granular upon the surface; it is then strained through a linen cloth, and what passes through is diluted with boiling water, and again filtered. Dissolve 4 parts blue vitriol and 1 part copperas separately in hot water, and add this solution to the solution of soap as long as it occasions any precipitate. This flocculent precipitate is a combination of the oxides of copper and iron with the margaric acid of the soap, the former giving a green and the latter a reddish-brown colour, the combination of the two resembling that greenish rust which is characteristic of ancient bronzes. When the precipitate is completely separated, a fresh portion of the vitriol solution is to be poured upon it in a copper pan, and boiled in order to wash it. After some time the liquid is poured off and the soap is washed with warm and afterwards with cold water, pressed in a linen bag, drained, and dried, when it is ready for use in the following manner:—

3 lb. pure linseed oil are boiled with 12 lb. finely-powdered litharge, and the mixture is strained through a canvas cloth and permitted to stand in a warm place until it becomes clear; 15 oz. of this, 12 oz. of the above described soap, and 5 oz. of fine white wax are mixed together at a gentle heat in a porcelain basin, by means of a water bath. The mixture must be kept some time in a molten state, to expel any moisture which it may contain. It is then applied by means of a paint-brush to the surface of the gypsum, which is heated to the temperature of about 200° F. After exposure to air for a few days, the surface is rubbed with cotton wool or a fine rag, and variegated with a few streaks of metal powder or shell gold. Small objects may be dipped in the melted mixture and then exposed to the heat of the fire until thoroughly penetrated and evenly coated with it.

Powders.—Bronze powders made of impalpable brass are applied upon metals to imitate bronze, and also upon articles of plaster of Paris, and ceramic wares. After the object has been cleaned, it receives a thin coat of fatty drying varnish, which is allowed to become nearly dry. The bronze powder is then laid on with a brush, and adheres strongly. After drying, cover it with a coat of transparent colourless varnish. This process is only suited to large pieces which are imperfectly finished, and will not do for reproductions intended to respect the small details.

(*a*) Verdigris, 4 oz.; tutty, 2 oz; corrosive sublimate, 1 dr.; borax, 1 dr.; nitre, 1 dr.; mix them to a paste with oil, and fuse in a crucible. The "tutty" here mentioned is sometimes called "putty" powder, and is an oxide of tin. (*b*) Mix together 100 parts copper sulphate, and 50 crystallised soda carbonate. Apply heat till they unite, powder the mass when cold, and add 15 parts copper filings, mix well, and keep at a white heat for 20 minutes; wash and dry the product.

Tin.—Clean the castings, and wash them with a mixture of 1 part each of copper and iron sulphates in 20 parts of water; dry and wash again with a solution of verdigris, 5 parts; in distilled vinegar, 11 parts. When dry, polish with colcothar.

Wood.—Make a concentrated solution of soluble glass of a strength of about 30° B. The article to be bronzed or decorated is first coated with a very thin film or layer of the solution of soluble glass, which is applied by a soft paint-brush, and the bronze or other powder is applied through a sieve; the articles are then dried by exposure to the atmosphere or artificial heat, after which the excess of powder that has not been absorbed by the soluble glass is removed by a brush. The bronze powder so applied will resist the effects of heat and of washing with alcohol, or of polishing by steel or agate burnishers. This is also particularly beneficial for decorating iron and porcelain stoves, inasmuch as the bronzing powder will not be affected by the heat of the stove. The gilding on the frames of pictures and looking-glasses when worn can also be restored in a few minutes by this process.

Zinc.—The zinc to be bronzed must receive an electro-deposit of brass, which is then dipped into a weak solution of copper sulphate for a red tinge. When dry, wet with a rag dipped into ammonia hydrosulphate, or a solution of potassium polysulphide, or copper protochloride dissolved in hydrochloric acid. After another drying, the surface is brushed over with a mixture of iron peroxide and plumbago, according to the tint desired. The brush may be slightly wetted with essence of turpentine, which aids the adhesion of the powders. The raised parts are strongly rubbed to uncover the brass. Afterwards give a coat of colourless varnish.

Cobalt Deposits. — The most beautiful cobalt plating may be obtained upon brass and copper, by employing in the battery—with two Bunsen cells—a moderately concentrated solution of the double chloride of ammonium and cobalt. This solution is prepared by dissolving 40 grm. crystallised cobalt chloride, and 20 grm. ammonium chloride, in 100 cc. water, with the addition of 20 cc. ammonia.

Copper Deposits. — These are produced either by simple dipping or by galvanic methods.

Dipping.—Copper deposits by dipping are seldom practised except upon iron, and are generally wanting in lasting qualities, since, from the thinness of the deposit, the iron is not protected against atmospheric influences.

(*a*) If the iron is steeped in a solution of copper sulphate, 3½ oz.; sulphuric acid, 3½ oz.; water, 1–2 gal., for a short time, it becomes covered with a coating of pure copper, having a certain adhesion; but should it remain there for a few minutes, the deposit of copper is thicker and muddy, and does not stand any rubbing. In this case, compress it by means of rollers or a draw plate, in order to impart a certain cohesion to the particles of copper.

(*b*) Small articles, such as hooks, pins, or nails, are coppered by jerking them about for a certain time in sand, bran, or sawdust impregnated with the above solution, diluted with three or four times its volume of water.

(*c*) Clean the iron by rubbing with cream of tartar, and afterwards with charcoal powder; place it in a bath of spirits of salts, diluted with 4 times its volume of water, in which a few drops of bluestone have been placed. After a few minutes have expired, withdraw the iron and rub it with a piece of cloth, then replace it in the solution, adding another portion of bluestone. By following out this plan, and adding at each immersion a new supply of bluestone, the layer of copper may be increased at pleasure. Lastly, introduce the coated iron into a solution of soda, then wipe clean and polish with chalk. The coating thus obtained will be firm and durable.

(*d*) Iron can be coppered by dipping it into melted copper, the surface of which is protected by a melted layer of cryolite and phosphoric acid. The articles to be coppered must be heated to the same temperature as the melted copper.

(*e*) Dip into a melted mixture of 1 part chloride or fluoride of copper, and 5 or 6 parts cryolite, and a little barium chloride. If the article when immersed is connected with the negative pole of a battery, it hastens the process.

(*f*) Dip in a solution of copper oxalate and soda bicarbonate, dissolved in 10–15 parts of water, acidified with some organic acid.

(*g*) The surfaces are cleaned with a brush and hydrochloric acid, and the objects are then left in water slightly acidified; they are afterwards placed in a bath composed of 25 grm. copper oxide, 170 grm. hydrochloric acid, ¼ litre of water, and ½ litre of alcohol. A regular deposit of copper takes place on the surface of the iron, the rapidity depending upon the proportion of the alcohol, which is the active agent, to the other ingredients. The iron may be coated with the aid of pure alcohol only, but in this case the deposit is very thin, and in the form of chloride, which is converted in the end into metallic copper. The chloride which adheres to the surface should be carefully brushed off after the operation, and the surface dried. If iron thus coated with copper is placed in a bath consisting of 10 grm. iron chloride and 1½ litre alcohol, in contact with metallic zinc, the surface is covered with a fine silvery deposit, which adheres firmly to the copper.

Galvanic.—Electro-deposits of copper are obtained by decomposing a double salt of copper with another base, such as the double cyanide of potassium and copper. This process is equally well adapted to all metals, and the deposits are fine, lasting, and their thickness is entirely regulated by the will of the operator.

(*a*) Dissolve about 16 oz. copper sulphate in 2 gal. water, and add a solution of soda carbonate until no more precipitate is formed; collect the green precipitate, copper carbonate, thus obtained upon a cloth filter, and wash it several times with water; then stir the washed copper carbonate in water, to which potassium cyanide is added until the carbonate is entirely dissolved, and the solution is colourless. It is well to add a small excess of cyanide, which will increase the conducting power of the liquor. This bath may be employed hot or cold, and requires an intense electric current for its decomposition. A copper plate or foil forms the anode, and as it slowly dissolves, nearly makes up for the loss of copper in the bath which has deposited on the negative pole. This anode must be removed when the bath does not work, because it will be dissolved even without an electric current, and the bath having been overcharged with copper, which is indicated by a blue or green colour, will require a fresh addition of cyanide to be in good order. This bath is neither economical nor very reliable. The following formula is preferable:

(*b*) Water, 2 gal.; copper acetate, crystallised; soda carbonate, crystals; soda bisulphite; potassium cyanide, pure, 7 oz. each. For this bath the copper acetate is put first into the vessel, and moistened with sufficient water to make a homogeneous paste. This salt, like flour, is wetted with difficulty, and will float on the surface of too great a body of water. The soda carbonate and some water are added to this paste, and, after stirring, a light green precipitate is formed; 3 pints more water are then added with the soda bisulphite, and the mixture becomes of a dirty yellow colour. Lastly, add the remainder of the water and the potassium cyanide. The electro-copper bath must be colourless. If, after the complete solution of the cyanide, the liquor is not entirely colourless, add more cyanide. If a perfectly limpid bath is desired, pass it through filtering paper, or decant it after settling. This bath requires an electric current of mediate intensity for its decomposition. The copper anode should have a surface nearly equal to that of the immersed objects. Large pieces are generally kept hanging and motionless in the bath, whilst small articles are moved as much as possible, which is always to be preferred, especially with warm baths. If it were always possible to obtain pure potassium cyanide, this formula would be satisfactory in every case. But it is very difficult to find a perfectly satisfactory potassium cyanide. The following formulæ require a cyanide containing from 70 to 75 per cent. of the real article:—

(*c*) Cold Bath for Iron and Steel.—Soda bisulphite and potassium cyanide, 18 oz. each; soda carbonate, 36 oz.; copper acetate, 17 oz.; aqua ammonia, 12½ oz.; water, 5½ gal.

(*d*) Warm Bath.—Soda bisulphite, 7 oz.; potassium cyanide, 25 oz.; soda carbonate and copper acetate, 18 oz. each; aqua ammonia, 10 oz.; water, 5½ gal.

(*e*) Hot or cold Bath for Tin, Cast Iron, or Large Pieces of Zinc.—Soda bisulphite, 10 oz.; potassium cyanide, 18 oz.; copper acetate, 12½ oz.; aqua ammonia, 7 oz.; water, 5½ gal.

(*f*) For small articles of zinc which are coppered in a perforated ladle, and in nearly boiling baths:—Potassium cyanide, 25 oz.; soda bisulphite, 3½ oz.; copper acetate, 16 oz.; aqua ammonia, 5⅓ oz.; water, 4–5½ gal. To prepare these different baths, dissolve all the salts in about 4 gal. distilled water, except the copper acetate and the ammonia, which are dissolved apart in the remaining gallon. These two solutions are mixed, and that of copper and ammonia, which was of a magnificent blue, must become entirely colourless. When the liquors are not colourless there is a deficiency of potassium cyanide, which must be added until entire decolourisation takes place. The bath is ready to work when subjected to the action of the electric current.

The cold baths are put into well-joined tanks of oak or fir wood, lined inside with gutta percha. The vertical sides are also covered with sheets of copper, which act as the soluble anode, and reach to just below the top edge of the tank. This anode is connected by the clean extremities of a conducting wire to the last copper or carbon—that is to say, to the positive pole. Fix a stout brass wire upon the top of the tank, without any point of contact with the soluble anode, and connect by a second wire with the last zinc or negative pole of the same battery. The objects to be coppered are suspended in the bath by copper wires, supported themselves upon a stout, clean, brass rod, the two extremities of which rest upon the brass conducting wire fixed upon the tank. Several of such rods are placed parallel to each other, and great care must be taken to prevent any contact with the anode, because the working of the bath would then be immediately stopped. When the thickness of the deposited copper is very small, the coat is sufficiently bright to be considered finished after drying. But if the operation is more protracted, the deposit has a more or less dead lustre on account of its thickness, and, if a bright lustre is desired, we must use the scratch-brush.

The hot baths are put into stoneware vessels heated in a water or steam bath, or into an enamelled cast iron kettle placed directly over a fire. The insides are also lined with an anode of copper connected with the positive pole of the battery, and the edges of the vessels are varnished, or support a wooden ring upon which rests a brass circle communicating with the negative pole. The objects to be electroplated hang from this circle. The hot process is much more rapid than the cold, and is especially adapted to those articles which are difficult to cleanse, because any remaining greasy substance is dissolved by the alkaline bath.

Parcels of small articles are not suspended in the bath; they should be connected with the negative wire in the hand of the operator, and stirred about in every direction in the bath. This agitation permits of the employment of an intense current, without danger to the beauty of the deposit. Small articles of zinc are placed in a stoneware perforated ladle, at the bottom of which is attached a zinc or copper wire, which is wound up around the handle, and is connected with the negative pole of the battery. It is sufficient that one of the small articles touches the wire for all of the others to be affected by the current, as they are in contact with each other. If the bottom of the vessel is metallic, the ladle is made to rest upon a porcelain or stoneware ring. During the operation the articles are often jerked in the ladle; this agitation changes the position and the points of contact of the objects. When the deposit is being made too slowly, bring up the bath by the addition of equal weights of copper acetate and potassium cyanide.

(*h*) For Silver. — Large pieces of silverware may be coppered in these baths. Very small articles are simply threaded upon a zinc or iron wire, or placed in a perforated ladle with granules or cuttings of either of these metals. Place the whole for a few minutes in a dilute but very acid solution of copper sulphate, the zinc or the iron is dissolved, and the copper is deposited upon the silver. When the article is intended to be gilded or silvered, it is immediately passed through the solution of nitrate of binoxide of mercury, rinsed in cold water, and placed in the electro-baths, without drying or scratch-brushing.

(*i*) Iridescent Copper on Iron.—The method of coating iron with copper in such a manner that the film of deposited metal shall give the appearance of iridescence is thus described by Dr. Weil:—35 parts crystallised cupric sulphate, or an equivalent amount of any other salt of copper, are precipitated as hydrated oxide by means of caustic soda; the oxide is added to a solution of 150 parts Rochelle salt, and dissolved in 1000 parts water. To this 60 parts best caustic soda, containing about 70 per cent. NaO, is added, when a clear solution of copper will be formed. Other alkaline tartrates may be substituted for the Rochelle salt above mentioned, or even tartaric acid may be employed, but in the case of tartaric acid or acid tartrates a small additional quantity of caustic alkali must be added, sufficient to saturate the tartaric acid or acid tartrate. Oxide of copper may also be employed precipitated by means of hypochlorite, but in all cases the proportions between the copper and the tartaric acid should be maintained as above, and it is advantageous not to increase to any notable extent the proportion of the caustic soda. The object to be coppered is to be cleaned with a scratch brush in an alkalino-organic bath, attached to the cathode, immersed in the coppering bath, and treated with the usual precautions, when it will become rapidly coated with an adherent film of metallic copper. As the bath gradually loses its copper, copper oxide as above prepared should be added to maintain it in a condition of activity, but the quantity of copper introduced should never exceed that above prescribed as compared with the quantity of tartaric acid the bath may contain. If the quantity of copper notably exceeds this proportion, certain metallic irisations are produced on the surface of the object. These effects may be employed for ornamental and artistic purposes. According to the time of the immersion, the strength of the current, and the proportion of copper to the tartaric acid, these iridescences may be produced of different shades and tints, which may be varied or intermingled by shielding certain parts of the object by an impermeable coating of paraffin or varnish, while the iridescent effect is being produced on the parts left exposed. All colours, from that of brass to bronze, scarlet, blue, and green, may be thus produced at will.

(*k*) For Zinc.—The use of cyanide baths for plating on zinc has the double disadvantage of being poisonous and expensive. Hess overcomes the objections by rendering the cyanide bath unnecessary. This he accomplishes by the use of an organic salt of copper, for instance a tartrate. Dissolve 126 grm. copper sulphate (blue vitriol) in 2 litres water; also 227 grm. potash tartrate and 286 grm. crystallised soda carbonate in 2 litres water. On mixing the two solutions a light blueish-green precipitate of copper tartrate is formed. It is thrown on a linen filter, and afterwards dissolved in ½ litre caustic soda solution of 16° B., when it is ready for use. The coating obtained from this solution is very pliable, smooth, and coherent, with a fine surface, and acquires any desired thickness if left long enough in the bath. Other metals can also be employed for plating in the form of tartrates. Instead of tartrates, phosphates, oxalates, citrates, acetates, and borates of metals, can be used, so that it seems possible to entirely dispense with the use of cyanide baths.

Gilding.—The application of a gold coating on various substances is performed by three separate methods, viz. by amalgamation, by dipping, and by cementing.

BY AMALGAMATION.—*Gold Amalgam.*—(*a*) In the centre of a charcoal stove put a crucible holding a given quantity of pure and dry mercury, and when the temperature has reached about

212° F., add ½ the weight of gold. Stir with an iron rod until the amalgam has acquired the consistency of butter, throw it into cold water, and keep it there for use.

(*b*) A quantity of mercury is put into a crucible or iron ladle, which is lined with clay, and exposed to heat till it begins to smoke. The gold to be mixed should be previously granulated, and heated red hot, when it should be added to the mercury, and stirred about with an iron rod till it is perfectly dissolved. If there should be any superfluous mercury, it may be separated by passing it through clean soft leather; and the remaining amalgam will have the consistence of butter, and contain about 3 parts of mercury to 1 of gold.

Applying Amalgam.—The metal to be gilt is previously well cleaned on its surface, by boiling in a weak picklo of very dilute nitric acid. A quantity of aquafortis is poured into an earthen vessel, and quicksilver is put therein; when a sufficient quantity of mercury is dissolved, the articles to be gilt are put into the solution, and stirred about with a brush till they become white. This is called quicking. During quicking by this mode a noxious vapour continually arises, which proves very injurious to the health of the workmen. To avoid that danger, dissolve the quicksilver in a bottle containing aquafortis, and leave it in the open air during the solution, so that the noxious vapour escapes into the air. Then a little of this solution is poured into a basin, and with a brush dipped therein stroke over the surface of the metal to be gilt, which immediately becomes quicked. The amalgam is now applied by one of the following methods:—(*a*) By proportioning it to the number of articles to be gilt, and putting them into a vessel together, working them about with a soft brush, till the amalgam is uniformly spread.

(*b*) By applying a portion of the amalgam upon one part, and spreading it on the surface, if flat, by working it about with a harder brush. The work thus managed is put into a pan, and exposed to a gentle degree of heat; when it becomes hot, it is frequently put into a pan, and worked about with a painters' large brush, to prevent an irregular dissipation of the mercury, till at last the quicksilver is entirely dissipated by the repetition of heat, and the gold is attached to the surface of the metal. This gilt surface is well cleaned by a wire brush, and then artists heighten the colour of the gold by the application of various compositions; this part of the process is called colouring.

(*c*) Mercury gilding will furnish gold with a bright or a dead lustre, scratch-brushed, ormolued, and with different shades. The amalgam should be about as hard as wax. This amalgam is crystalline, and a certain crackling sound is heard when the crystals are crushed between the fingers. A stock of amalgam is generally prepared in advance, and is divided into small balls of nearly equal size, the value of which is ascertained from their number, and from the total weight of gold employed. These balls are kept in water, but should not remain too long without being used, as the different parts do not then present the same composition. The amalgam is spread with the finger upon a flat, hard stone, called the gilding stone; and having dipped a scratch-brush of stout brass wire into a solution of nitrate of binoxide of mercury until it becomes completely white, it is passed over the amalgam, a portion of which is carried away. The object, previously well cleansed, is scratch-brushed in every direction, and the brush must be frequently dipped into the mercurial solution to facilitate the regular and even spreading of the amalgam. This operation requires great care to obtain a uniform coat upon the hollow and raised parts. When the back part of a piece does not require gilding, the flat outline, and the back edge, should be gilt, so that the naked copper shall cause no injury in the subsequent operations. The article, when uniformly covered with the amalgam, is heated upon a charcoal fire without draught, which rests upon a cast-iron plate. It is advisable to employ a gilding forge, which allows the workman to watch the operation from behind a glass frame, which protects him from the mercurial vapours. The entire attention is now required for watching the process. With the left hand covered with a thick glove of buckskin, turn the piece in every direction upon the fire, and, as the mercury disappears, with the right hand strike the article in every direction with a brush, the handle and the bristles of which must be long, to equalise the gilding, and to push the remaining amalgam upon those parts which appear less charged with it. When all the mercury has volatilised, the gilding has a dull greenish-yellow colour, resembling that of boxwood; examine whether the coat of gold is continuous. Should a few empty places appear, add more amalgam, and heat the whole again. The next operation is scratch-brushing, which furnishes a pale green colour, and requires another heating for arriving at the desired shade. The reheating should expel any remaining mercury, and produce a fine orange-yellow colour. In case a bright lustre is required, submit the object, with the aid of heat, to the ormolu process. To obtain dead lustre, the object is firmly fixed to an iron rod, by wire of the same metal, and smeared with a hot paste for dead gilding, composed of saltpetre, common salt, and the double sulphate of alumina and potash. The whole is heated upon a brisk charcoal fire, without draught, and moved about until the mixture dries and begins to fuse, when the article is immediately placed in a barrel half filled with water. The covering of salts dissolves, and the dead lustre appears; this operation requires a certain amount of practice. The gilding must be strong to stand the dead lustre process, especially when the first trial is not successful. The red lines left by the iron wire disappear by plunging the object into a not too diluted solution of nitric acid, or pure hydrochloric acid. Mercury gilders do not employ pure gold; what they use is previously alloyed with a certain portion of copper or silver. With the latter metal the gilding is green.

(*d*) Grecian Gilding.—Equal parts of sal-ammoniac and corrosive sublimate are dissolved in spirit of nitre, and a solution of gold is made with this menstruum. Silver brushed over with it turns black, but on exposure to a red heat it assumes the colour of gold.

Gilding in Colours.—The principal colours of gold for gilding are red, green, and yellow. These should be kept in different amalgams. The part which is to remain of the first colour, is to be stopped off with a composition of chalk and glue; the variety required is produced by gilding the unstopped parts with the proper amalgam, according to the usual mode of gilding. Sometimes the amalgam is applied to the surface to be gilt, without any quicking, by spreading it with aquafortis; but this depends on the same principle as a previous quicking.

Cold Gilding with the Rag.—Dissolve finely laminated pure gold in aqua regia made of 5 parts nitric acid, 2 sal-ammoniac, $\frac{1}{2}$ saltpetre. Heat carefully upon a gentle fire; when all the gold has disappeared, pour the cooled contents of the flask into a flat-bottomed stoneware pan. Into this liquor, place one upon the other, and in sufficient quantity, squares of linen cloth; strike them with a glass rod, in order that they may equally absorb the gold chloride. Each square of cloth is taken out with wooden pincers, well drained, and spread for drying in a dark chamber. When nearly dry, each piece of cloth, supported upon glass rods, is placed on top of a charcoal fire, and soon takes fire. The combustion is aided by the presence of the saltpetre, and is finished upon a marble slab. Grind the ashes under a muller, collect and keep them between the folds of a parchment leaf, around which a wet cloth has been folded. The powder is then ready to use; mix it upon a slab with a few drops of water, and with this paste rub the well-cleaned surfaces of the silver to be gilt. The smooth surfaces are rubbed with the thumb, the fillets or grooves with a fine cork cut to the proper shape, and the corners or angles with a stick of soft wood, such as linden or poplar; the articles are then burnished. This gilding is very thin, but quite resisting, especially after the action of the burnishing tool, which forces the gold into the pores of the silver. If a red shade be desired, add a small proportion of pure copper to the gold to be dissolved in aqua regia.

Gilding with a Dead Lustre.—(*a*) By the slow deposit of a large proportion of gold. This gilding is very durable, but dull and earthy in appearance, and is costly.

(*b*) By acids; giving a dead lustre to the metallic surface, before gilding, and by the processes indicated in the cleansing operations. This is employed for small articles, or when gilding by dipping, for bronze articles, or large embossed work.

(*c*) With frosted silver, by depositing upon the object to be gilt a coat of frosted silver, and then gilding in a good bath; this method is expensive, the burnished parts are greenish, and the intermediary coat of silver is more easily blackened by sulphur fumes than gold.

(*d*) By decomposing a solution of copper sulphate by a battery, depositing a coat of this metal, which possesses a pink dead lustre. The whole is rapidly passed through the compound acids for a bright lustre, and the mercurial solution, and then gilt in a good bath. When the dead lustre obtained in the bath is perfect, the compound acids may be dispensed with, and merely place the article in the mercurial solution before it is gilt. This mode is generally preferred, as the gilding is very handsome in lustre and colour. The burnished parts will be red, if vinegar or soap-water is used; and of a fine yellow colour, if the burnishing tool be wetted with a decoction of flax-seed, or of marsh-mallow root. If the gold deposit is of insufficient thickness, it will blacken in time, by the oxidation of the intermediate coat of copper.

(*e*) Mercury furnishes the most durable gilding, although costly.

(*f*) For Zinc.—With tin solder fill all the holes and the smallest defects which may exist in the zinc object, and, at the same time, remove all seams, burrs, and rough spots. Afterwards, scour the piece by passing it, for a few seconds only, through a boiling solution of 100 parts water and 5-6 caustic soda; if left too long in this caustic lye it will spoil the polish of the zinc, which dissolves. After this scouring, the object is rinsed in fresh water. It is then steeped for ½ minute in a pickle composed of 1 part sulphuric acid, and 10 water, and lastly rinsed in boiling water. Then place the object in a cold or warm electro-bath of copper or brass, for a few moments, until it is covered with a thin metallic coating, which is deposited very uniformly if the object has in it no tin solder, and is perfectly cleansed; the deposit is black and dull on those parts which have been soldered, or imperfectly cleansed. In this case, thoroughly scratch-brush the article, and dip again into the electro-bath until the deposit is sufficiently thick. Most gilders use a warm bath for the first coating, scratch-brush, and complete the deposit in a cold bath. If a bright gilding is desired, the article may be rinsed in fresh water, and then dipped into an electro-gilding bath.

Gilding with a partly Dead, partly Bright Lustre.—(*a*) Gild those parts with the amalgam which are intended for a dead lustre, and heat, scratch-brush, and reheat to the orange-yellow colour. Then, with the battery, give a sufficiently strong gold deposit to the whole, without regard to the parts already mercury-gilt; scratch-brush all the surfaces carefully, and smear the electro-gilt portions first with a thin mixture of water, glue, and Spanish white, and afterwards with a thick paste of yellow clay. After drying, cover the mercury-gilt portions with the paste for dead gilding, and proceed as already described. The Spanish white, &c., are dissolved in a dilute solution of hydrochloric acid. The glued paste is to preserve the electro-gilt portions from the heat; these are again wire-brushed with all the care necessary for not scratching the dead lustre. Brushing to finish. This method will sometimes produce red spots on those places which have been heated too much, or where the coat of gold was not thick enough.

(*b*) Gild with the amalgam, and bring up the dead lustre upon those portions which are to receive it, and preserve them entirely with the resist varnish. After thorough drying, cleanse the object by dipping it into acids, in the usual manner, and gild in the electro-bath. The resist varnish stands all these acids and solutions. When the desired shade is obtained, dissolve the varnish with gasoline or benzine, which, unless there has been friction applied, does not injure either the shade or the velvety appearance of the dead lustre. Wash in a hot solution of potassium cyanide, then in boiling water, and allow to dry naturally. The resist varnish may also be removed by allowing the object to remain for a time in concentrated sulphuric acid at 66° B., which has no action whatever upon the gilding. In this case, washing with cyanide is unnecessary, pure water is sufficient. Gilding with a dead lustre, whatever process is employed, only suits those objects which will never be subjected to friction. Even the contact of the fingers injures it. A new freshness is imparted to old dead gildings by a washing in caustic lye, and then in a dilute solution of nitric or sulphuric acid. This process removes dirt, grease, dust, and smoke, but will not remedy scratches. In the latter case, the objects must be scratch-brushed, and then heated with the composition for a dead lustre.

Covering Copper Bars with Gold, so as to be rolled out into Sheets.—First prepare ingots or pieces of copper or brass, in convenient lengths and sizes. Then cleanse them from impurity, and make their surfaces level. Prepare plates of pure gold, or gold mixed with a portion of alloy, of the same size as the ingots of metal, and of suitable thickness. Having placed a piece of gold upon an ingot intended to be plated, hammer and compress them both together, so that they may have their surfaces as nearly equal to each other as possible; then bind together with wire, in order to keep them in the same position during the process required to attach them. Afterwards mix silver filings with borax, to assist the fusion of the silver. Lay this mixture upon the edge of the plate, and next to the ingot of metal. Having prepared the two bodies, place them on a fire, where they must remain until the silver and borax placed along the edges of the metals melt, and until the adhesion of the gold with the metal is perfect. Remove the ingot carefully from the stove. By this process the ingot is plated with gold, and prepared ready for rolling into sheets.

BY DIPPING.—It is not always necessary in electrogilding to use a battery, for a salt or acid liquor is enough to produce electricity; thus it is sufficient to plunge the articles, attached by zinc wires, into gold baths prepared for the use of batteries, to have the operation taking place in the same manner as with a separate battery. Electrogilding in the cold is employed for large pieces, such as clocks; whilst electrogilding by heat is more adapted to the gilding of small articles, such as forks and spoons. The deposits produced by hot gilding are more smooth and clean, the colour is deeper, and the articles when removed from the bath may not require colouring; and with the same quantity of gold, gilding by heat is much more durable than that obtained from cold baths. Steel, tin, or lead can be gilt in hot baths, but not in cold.

Baths.—(*a*) Distilled water $2\frac{1}{5}$ gal.; potassium cyanide, ordinary 70 per cent., $10\frac{1}{2}$ oz.; pure gold, $3\frac{1}{2}$ oz.; aqua ammonia, $17\frac{1}{2}$ oz. Heat the gold in a glass flask with 9 oz. pure hydrochloric acid, and $4\frac{1}{2}$ oz. pure nitric acid. When the gold is dissolved, continue the heat in order to expel the acid fumes, and until the colour of the liquid is dark red, nearly black. Remove from the fire, and dissolve the crystalline mass formed in cooling in 3–4 pints water, and pour into a large porcelain dish.

Add the ammonia, which produces an abundant yellow precipitate of gold ammonium; pour upon filtering paper, and the filtered liquid, which still contains traces of gold, is kept with the saved waste. Wash the precipitate remaining upon the filter several times with cold water, until it no longer smells of ammonia. It must not be dried, as it is a fulminating mixture, and consequently very dangerous. Next dissolve in the vessel used as a bath the potassium cyanide in the distilled water. Filter, and add the wet gold ammonium, which rapidly dissolves when stirred, and forms a clear gold bath. But before using it cold, the ammonia should be expelled by boiling for about one hour. For a newly-prepared cold electrogilding bath, the ordinary potassium cyanide is preferable, on account of the potash it contains, which renders the liquor a better conductor of electricity. But for the preservation of the strength, the pure cyanide is better, as it possesses the advantage of a constant composition, and does not load the solution with foreign salts. The gold solution for maintaining the metallic strength of the bath is prepared as follows:—Transform the gold into precipitate of gold ammonium, as above described, place it in water, 2 pints water to 4 oz. gold, then add potassium cyanide until the liquor is colourless. If there is not sufficient water with the gold ammonium, the liquor will be dark red, and will not be decolourised by cyanide.

(*b*) Distilled water, 2⅕ gal.; potassium cyanide, pure, 7 oz.; or ordinary cyanide, according to strength, 10–14 oz.; pure gold, 3½ oz. Make a neutral gold chloride, as in the preceding formula, and, when cold and crystallised, dissolve it in 3½ pints water. Filter if needed. Dissolve the cyanide in 14 pints water; filter, and mix the two solutions, which become colourless. When it is possible to boil this bath for ½ hour before using it, it becomes a better conductor of electricity, and the gilding is more uniform. Its strength is maintained by additions of neutral gold chloride and pure potassium cyanide, 1–1½ pure cyanide to 1 of gold. Both the above baths may be diluted with once or twice their volume of water; the gilding will remain fine, but the proportion of gold deposited will be less in a given length of time.

(*c*) Yellow prussiate of potash, 7 oz.; pure potash carbonate, 5 oz.; sal ammoniac, 1 oz.; pure gold transformed into chloride, ½ oz.; water, 2⅕ gal. Boil all the salts together, less the gold chloride, separate by filtration the precipitate of iron carbonate, then add the gold chloride dissolved in a little water, and allow the bath to cool off. Any kind of gold salt, and the oxide, or even finely-powdered metal, may take the place of the gold chloride; but the latter is preferred on account of the facility of its preparation, and of its solubility. Any kind of gold salt will be transformed into cyanide by the potassium cyanide. The small proportion of the potassium chloride resulting from the transformation of the gold chloride into cyanide does not prevent the good working of the baths. The addition of a little prussic acid produces a brighter, but thinner gilding. The indicated cyanides may be replaced by the cyanides of sodium, calcium, and ammonium.

(*d*) Cold gilding baths are generally kept in porcelain or stoneware vessels; but for large volumes of liquor, use wooden troughs lined with gutta-percha plates. The sides of the troughs support anodes of laminated gold, which dip entirely into the liquor, and are held by small platinum wires; they are connected with the positive pole of the battery. Suspend the articles by means of metallic slinging wires to a movable frame of clean brass rods connected with the negative pole. The deposit of gold should be pure yellow, but it has sometimes a dull earthy grey colour. In that case scratch-brush it with the greatest care, and then pass it through the ormolu colouring. The gold anode conducts the electricity, and also maintains the metallic strength of the bath up to a certain point; but it is necessary to add now and then either oxides or chloride of gold, and a certain proportion of potassium cyanide, to make up for that transformed into potash carbonate and ammonia cyanide. The proportion of cyanide is about double that of the gold chloride added; this is ascertained by the colour of the bath and the shade of the deposit; if the proportion of the gold chloride is too great, add more cyanide. If gold predominates, the deposit is quite black or dark red; when the cyanide is in excess, the gilding is very slow and grey, and it will sometimes happen that pieces already gilt will lose their gold. When the bath is not in use, the gold anode must be removed from it, otherwise it will be dissolved. If the anode were partly immersed in the bath, it would be rapidly cut at the level of the liquid; for this reason use platinum wires, which are not acted upon. It is remarkable that the solution of cyanides, even without the action of the electric current, rapidly dissolve all the metals except platinum in the cold or at a moderate temperature, and that at the boiling point they have scarcely any action upon the metals.

(*e*) Cold electrogilding should be done slowly; and it is necessary to often look at the pieces in the bath, and scratch-brush those with an irregular deposit, or with dark spots. The intensity of the current should be often changed by increasing or diminishing the number of the elements, or the strength or the volume of the liquors in the battery. With too much intensity in the current, the deposit is black or red; it is yellow with the proper amount of electricity. With a weak current those portions opposite the anode only get covered with gold; it is well to change the position of the objects often, in order that the deposit be regular. With a freshly-prepared bath, it may happen that surfaces already gilt will lose their gold by changing their positions. This is a sign that the bath contains too much cyanide, and too little gold, or that the electric current is too weak.

(*f*) When the deposit obtained in cold baths is unsatisfactory in appearance, although the quantity is sufficient, the proper shade may be imparted by:—(1) The gilt article is steeped in a solution of nitrate of binoxide of mercury, until it has become white. It is heated afterwards to volatilise the mercury, and scratch-brushed. (2) Place the article in concentrated sulphuric acid, then heat it until abundant white fumes are disengaged, throw it, still hot, into a weak pickle of sulphuric acid. In this case, the acid has destroyed the organic impurities which may exist in the deposit, and reduces the subsalts of gold to the metallic state. (3) Smear the article with a thick paste of water and powdered borax, or with lime biphosphate of the consistency of honey, and heat until igneous fusion takes place. Then put the article into dilute sulphuric acid, which dissolves the borax or the biphosphate, and leaves the gold with its natural bright lustre. When, after scratch-brushing small gilt articles, their colour is not entirely satisfactory, it may be improved by plunging the articles again into the bath but for an instant, and then immediately into boiling water. For gilding German silver, the solution should be worked at rather a low temperature, and with a less surface of anode. The solution should be just so weak in precious metal, that the German silver will not precipitate the gold without the aid of the battery; otherwise the deposit will take place so rapidly that the gold will peel off when being burnished or scratch-brushed.

(*g*) Gold electroplating in hot baths is more regular, more rapidly obtained, and possesses a deeper shade than that by cold baths. Crystallised soda phosphate, 21 oz.; soda bisulphite, $3\frac{1}{2}$ oz.; pure potassium cyanide, $\frac{1}{3}$ oz.; pure gold, transformed into chloride, $\frac{1}{3}$ oz.; distilled water, $2\frac{1}{5}$ gal. This is satisfactory for electrogilding silver, bronze, and other alloys rich in copper.

(*h*) For gilding wrought and cast iron and steel directly, without a previous coat of copper, the bath is modified as follows:—Distilled water, $2\frac{1}{5}$ gal.; soda phosphate, $17\frac{1}{2}$ oz.; soda bisulphate, $4\frac{1}{2}$ oz.; pure potassium cyanide $\frac{1}{6}$ oz.; gold transformed into chloride, $\frac{1}{3}$ oz. The proportion of gold indicated is that of the metal employed and it is not necessary to mind the weight of the chloride, if the proper amount of gold is dissolved in aqua regia:—10 parts metallic gold correspond to about 18 of neutral chloride, or to 22 of acid chloride such as is usually sold. Steel articles, after cleansing by alkalies, must be passed rapidly through a very dilute solution of hydrochloric acid, wiped, and dipped into a very hot bath with an intense galvanic current at the beginning, which is gradually diminished by partly withdrawing the platinum anode. Small articles of steel, such as pens, or watch hands are threaded on a thin brass wire, and separated one from the other by glass beads. After cleansing, they are put into the boiling bath, rinsed, dried, and polished in hot and dry saw-dust. It is preferable to give zinc, tin, lead, antimony, or the alloys of these metals, a previous coat of copper, or to begin the gilding in a hot gold electro-bath, nearly worn out, and to scratch-brush the articles carefully. The gilding is completed in a new hot bath, with a strong current.

Put four-fifths of the distilled water into a porcelain dish, or an enamelled cast-iron kettle, heated over a charcoal stove, and dissolve in it, by the aid of stirring, the crystallised soda phosphate. When this is entirely dissolved, remove the liquor from the fire, filter if necessary, and allow it to cool off. Place the gold in a glass flask, with $\frac{1}{2}$ oz. pure nitric acid and 1 oz. pure hydrochloric acid. Heat slowly until the gold has dissolved, and then more rapidly to expel the excess of acid. There should remain a thick liquid of a blackish-red colour. Remove the flask from the fire, and by cooling the contents form a brown-red crystalline mass. The cooling is important. Dissolve in a porcelain dish, in half the remaining water, the soda bisulphite and the potassium cyanide. Then dissolve the neutral gold chloride in the remaining water, and pour it slowly, stirring with a glass rod, into the cold solution of soda phosphate; add the solution of bisulphite and cyanide. The whole liquor soon becomes colourless; the bath is then ready. If the gold chloride were thrown into the solution of soda phosphate while hot there would be danger of a partial reduction of the gold in the form of a metallic powder.

The hot electrogilding baths for small quantities of liquor are kept in porcelain dishes, but for large baths use enamelled cast-iron kettles. The temperature may vary from 120°–175° F. Small articles, such as jewellery, are kept in the right hand with the conducting wire, and plunged and agitated in the bath. The left hand holds the anode of platinum wire, which is steeped more or less in the liquor, according to the surface of the articles to be gilt. Large pieces are suspended from one or more brass rods, and are not moved about. The gilding is very rapid, and a sufficient thickness is obtained after a few minutes. The shade of the gold deposit is modified by the amount of the platinum anode dipping into the liquor. If it dips but a little, relatively to the surface of the articles, the gilding is pale; by immersing it more, the shade will become deeper and deeper until it is red. The platinum anode is connected by a conducting wire to the positive pole of the battery, and the conducting wire starting from the negative pole, touches or supports the articles to be gilt. As a rule, it is preferable to replace the impoverished baths by fresh ones, instead of keeping up their strength by additions of metal, especially for small articles. When gilding large pieces, maintain the strength of the baths by successive additions of gold chloride, or, what is better, of equal parts of gold ammonium and pure potassium cyanide. In this manner baths may be made to last a long time, but they are open to the inconvenience of furnishing a red or green gilding, if many articles of copper or of silver have been gilt in them. Articles of copper, or its alloys, should be perfectly cleansed, and may be passed through a very diluted solution of nitrate of binoxide of mercury.

(*i*) Silver requires to be heated, dipped, and perfectly scratch-brushed. For this metal the gilding should be strong, in order to prevent the corners and raised parts from becoming white and bare; and it is a good precaution to give it a coat of copper or brass, or a first gilding in an old bath. Soda phosphate, 14 oz.; soda bisulphite, $3\frac{1}{2}$ oz.; potash bicarbonate and caustic potash, $1\frac{3}{4}$ oz. each; potassium cyanide and pure gold for neutral chloride, $\frac{1}{2}$ oz. each; distilled water, $2\frac{1}{5}$ gal. All the substances except the gold chloride may be dissolved together, and filtered if necessary; then the solution of gold chloride is added. This bath is heated at 120°–140° F. and produces a very fine gilding, but it requires an intense electric current. It does not suit for the direct gilding of iron or steel.

(*k*) Yellow prussiate of potash, $5\frac{1}{4}$ oz.; potash carbonate, pure, $1\frac{3}{4}$ oz.; ammonia hydrochlorate, $\frac{2}{3}$ oz.; pure gold for neutral chloride, $\frac{1}{3}$ oz.; water, 1 gal. Dissolve the first three salts in hot water, and filter the solution; after cooling, add the gold solution, boil for $\frac{1}{2}$ hour, taking care to replace the evaporated water.

(*l*) Pure potassium cyanide, $1\frac{3}{4}$ oz.; pure gold, for neutral chloride, $\frac{1}{3}$ oz.; water, 5 pints. Dissolve the gold chloride in the whole of the water, and add the cyanide, which dissolves and makes the liquor colourless. This bath may be employed with little regard to temperature, and is simple in its ingredients. Unfortunately it is not uniform in its working, as it will ungild one face of the object while the other face becomes gilt, or may produce a red gilding at the bottom and a yellow one at the top. These inconveniences will partly disappear by a long ebullition.

(*m*) Distilled water, 17 pints; potash or soda pyrophosphate, 28 oz.; hydrocyanic (prussic) acid, $\frac{1}{3}$ oz.; crystallised gold perchloride, $\frac{2}{3}$ oz. The soda pyrophosphate is most generally employed, and is obtained by melting, at a white heat, the ordinary crystallised soda phosphate. The soda pyrophosphate may be obtained in the form of crystals, which is a proof of definite composition. The quantity of chloride represents a little more than $\frac{1}{3}$ oz. pure gold treated by aqua regia. Put 16 pints distilled water in a porcelain vessel, or an enamelled cast-iron kettle, and add, by small portions at a time, and stirring with a glass rod, the pyrophosphate; heat, filter, and let it cool down. The gold chloride is prepared by introducing into a small glass flask pure gold finely laminated, $\frac{1}{3}$ oz.; hydrochloric acid, pure, nearly 1 oz.; nitric acid, pure, $\frac{1}{2}$ oz. The flask is slightly heated, effervescence and abundant nitrous vapours result, and in a few minutes the gold has entirely disappeared, leaving a reddish-yellow liquor. The flask is then put upon a sheet of iron, with a hole in its centre, and supported by a tripod. The whole is heated by a gas or spirit lamp to evaporate excess of the acids; too much acidity may cause great irregularities in the working of the bath, and even prevent its action altogether. An excess of nitric acid causes a jumping of the heated liquors, and may overthrow the whole; it is preferable to have the hydrochloric acid predominating. The evaporation is finished when vapours escape slowly from the flask, and when the liquid has become of an oily consistency and of a deep red colour. The flask is then removed from the fire by wooden pincers, and set to cool upon a ring of plaited straw. If a more rapid evaporation is desired, heat the flask over ignited charcoal, or the spirit lamp; agitate the liquid to prevent any of the gold from returning to the metallic state. Well-prepared gold chloride, when cold, forms a saffron-yellow crystalline mass. If the colour is red, it has been too much evaporated, and will do very well for electro-baths, but for dipping baths it must be heated again after a small addition of the two acids. If the gold perchloride, by too protracted a heat, has passed to the state of insoluble protochloride, or even of metallic gold, the treatment must be begun again with the indicated mixture of pure nitric and hydrochloric acids. The perforated sheet of iron, upon which the flask rests, is intended to prevent the action of heat upon the sides of the vessel, which will decompose the films of gold chloride wetting the flask at these places. When the gold chloride is cold and crystallised, dissolve it in the flask with a little distilled water, and pour the solution through a paper filter held in a glass funnel into a clean bottle; this is to separate a small quantity of silver always found in the gold of the trade. Rinse the flask and filter with the unemployed water, so as to get all the gold into the bath. Pour the filtered solution of gold chloride into the cooled one of pyrophosphate, and stir with a glass rod. Lastly, add the hydrocyanic acid, aud the bath is heated nearly to the boiling point for use. If the solution of pyrophosphate is still tepid, add the hydrocyanic acid before the gold chloride. Hydrocyanic (prussic) acid is not absolutely necessary; but, without it, the bath is too easily decomposed, and the gold is too rapidly precipitated upon the objects placed in it. When the solutions are mixed in the cold, the liquor is yellow or greenish-yellow; but becomes colourless by the increase of temperature. If the liquor becomes violet, it is an indication that there is too little hydrocyanic acid; add it, drop by drop, until the liquor becomes colourless. An excess of this acid is objectionable, but there is a very simple method of keeping the baths in good working order, by adding prussic acid gradually to those too rich in gold; or correcting any excess of prussic acid with a small proportion of gold chloride, until the gilding is produced without difficulty and of the proper shade. Thus prepared, the bath will produce very fine gilding upon well-cleansed articles, which must also have passed through a very diluted solution of nitrate of binoxide of mercury, without which the deposit of gold is red and irregular, and will not cover the soldered portions. The articles are supported by a hook or in a stoneware ladle perforated with holes, or in brass gauze baskets; they must be constantly agitated whilst in the bath. Gilders usually employ three baths, placed in close proximity to each other, and heated upon the same furnace; the first bath is one deprived of gold by a previous operation, and is used for removing all excess of acid which may remain upon the articles: the second bath still retains some gold, but not enough to give a sufficiently rich gilding. The pieces passed through it begin to receive the deposit, which will be finished in thickness and shade in the third bath. A gas furnace, easy to manage, and clean in its working, may be arranged by having a properly supported sheet-iron plate, with holes cut out where the kettles are to stand. Under each kettle place suitable gas burners; when the baths have been heated nearly up to boiling point, lower the gas, so as not to increase the temperature. This method produces much more gilding with a given quantity of gold, than one bath alone. The gilding is done in a few seconds; the finishing operations consist in rinsing in fresh water, drying in dry and warm saw-dust, and burnishing, if desired.

(*n*) The following solution, to be used at a temperature of 120°–180° F., is recommended by Rod:—crystallised soda phosphate, 60; soda bisulphate, 10; potassium cyanide, 1; gold chloride, 2½; distilled or rain water, 1000 parts by weight. To prepare this bath properly, the water should be divided into three portions, viz., one of 700 parts and two of 150 parts. The sodic phosphate is dissolved in the first portion, the gold chloride in the second, and the soda bisulphate and potassium cyanide in the third. The two first portions are gradually mixed together, and the third is afterwards added. With this solution Rod uses a platinum anode (a wire or strip), adding fresh portions of the gold salt as the solution becomes exhausted.

(*o*) Dr. Ebermayer gives a formula for gilding metallic articles so as to look like polished gold, by simply dipping them into a warm solution. Dissolve 10 grm. gold in 40 grm. hydrochloric acid and 15 grm. nitric acid; stew down, letting as much of the acid escape as possible; then throw down the gold as fulminating gold by means of spirit of ammonia; filter, and wash. In the meantime dissolve 100 grm. potassium cyanide in as little water as possible, and then dissolve the gold upon the filter with the cyanide solution. Pour this solution again and again over the filter until all the brown particles are dissolved, when the gilding solution is prepared by the addition of 1 litre distilled water. Into this solution, while warm, dip the metallic object to be gilded, and when drawn out it will have all the appearance of polished gold.

(*p*) The bath is prepared in a cast-iron kettle, turned clean and smooth inside on the lathe, and gilt by the protracted ebullition of nearly spent gold baths. Water, $3\frac{1}{2}$ gal.; potash or soda bicarbonate, $\frac{1}{3}$ oz.; pure metallic gold, transformed into chloride, $4\frac{1}{4}$ oz. The whole is boiled for at least 2 hours, and fresh water is added to replace that evaporated. A part of the gold, in the form of a violet-black powder, precipitates, and requires the cooling and decanting of the liquor. This is boiled again, and the gilding is proceeded with, in the same manner as before described, except that the mercurial solution should be more diluted than for baths of pyrophosphates. The operation is finished when about half of the gold in the liquor is deposited. The remainder goes to the saved waste. The bicarbonate process is inferior in most respects to the pyrophosphate, and is now rarely used.

(*q*) This bath should be employed only as a complement to the cleansing process, before a more resisting gilding, as its results have little durability. Water, 2 gal.; potash bicarbonate, 7 oz.; caustic potash, 63 oz.; potassium cyanide, 3 oz.; metallic gold to be transformed into chloride, $\frac{1}{3}$ oz. The whole is brought up to the boiling point, and a pale gilding is obtained even upon articles perfectly cleansed, and without using nitrate of binoxide of mercury. It is possible to add $\frac{1}{8}$ oz. gold chloride several times to this bath without any other substance. Afterwards maintain it at the proper strength by additions of gold and salts in the above proportions, and it will last for an indefinite period. This bath will gild about 140 oz. of small jewellery with $\frac{1}{30}$ oz. gold, whereas a pyrophosphate bath gilds only about 35 oz. of small articles with the $\frac{1}{30}$ oz. gold extracted from the liquor.

Dissolving Gold in Aqua-Regia.—Take aqua-regia, composed of 2 parts of nitric acid, and 1 of muriatic acid; or of 1 part sal ammoniac, and 4 of aquafortis; let the gold be granulated, put into a sufficient quantity of this menstruum, and exposed to a moderate degree of heat. During the solution, an effervescence takes place, and it acquires a beautiful yellow colour which becomes more and more intense, till it has a dark golden or orange colour. When the menstruum is saturated, it is very clear and transparent.

Management of Hot Baths.— The baths may be more concentrated, the quantity of water may be diminished, without changing the proportions of the salts and of the gold. But it is preferable to use dilute solutions, which deliver the metal in smaller quantity in a given time, but more homogeneous in substance. The articles should be kept in constant agitation; there is then no difference of specific gravity among the layers of the liquor, and the gilding possesses a uniform colour. A foil or a wire of platinum is preferred to a soluble anode of gold when electro-gilding by the aid of heat, as it is not dissolved, and is more handy for regulating the intensity of the current, by immersing it more or less in the liquid. Thus with the same bath and battery three different shades can be obtained; a pale colour, with the anode dipping but slightly; a yellow colour, when the immersion is greater, and a red gold, if the whole anode is in the liquor. In a bath of pink gold, composed of gold, copper, and silver, by increasing or diminishing the length of the platinum anode in the liquor, the deposit will have a white, yellow, or red shade, as the various metals require different degrees of intensity for their reduction in the galvanic current.

Colouring.—If the gilding is dull and irregular in colour, melt together in their water of crystallisation, at about 212° F., equal parts of iron, zinc, alumina, and potash sulphates, and saltpetre. Cover the articles with the mixture, and put them into a cylindrical and vertical grate. This is placed in the centre of a furnace, where the charcoal burns between the sides and the grate which holds the articles. When the moistened finger is presented to one piece, and a slight hissing sound is heard, the heat has been sufficiently raised; put all the articles rapidly into very dilute sulphuric acid, where the coating of salts is quickly dissolved; the articles present a warm, uniform shade of colour. If the copper articles are not entirely gilt by the first operation, the ungilt portions will show themselves by a red colouration, and the articles must then be deprived of gold, cleansed, and gilt anew. Sometimes, when the first gilding is imperfect, instead of colouring by the process just described, the articles are placed for a few moments into the electro-bath. For articles which require a good plating there is an easy method by this process of obtaining as good results as by the battery; it consists in gilding several times, by dipping; before each dipping, the article is passed through solution of nitrate of binoxide of mercury. Gilding by dipping is superior to that by electricity in depth of shade, brightness, and especially in not scaling off, as the deposit is of pure gold only.

Green and White.—(*a*) These shades may be graduated at will, and are obtained by adding, drop by drop, until the desired shade is arrived at, to the bath of double pyrophosphate of soda and gold, a solution of silver nitrate. For the solution of silver nitrate, dissolve in 5 oz. distilled water, ½ oz. silver nitrate, crystallised, or lunar caustic. Before gilding green or white, yellow gild the objects in the ordinary bath, then pass them rapidly through the mercurial solution, and, lastly, dip them into the gold bath holding the silver nitrate, which parts rapidly with its silver upon the first articles steeped in it. It is necessary to maintain the constancy of the shade by the addition of a few drops of the silver solution when required.

(*b*) Add to one of the above baths a solution of the double cyanide of silver and potassium, until the desired shade is obtained. The tints will vary from a leek-green to a very pale whitish-yellow. This kind of gilding mixed upon the same articles with red, yellow, or pink gold, will produce splendid effects of contrast, especially upon chased parts, where the green gold has a velvety lustre.

(*c*) 1 oz. 10 dwt. saltpetre; 1 oz. 4 dwt. sal ammoniac; 1 oz. 4 dwt. Roman vitriol; and 18 dwt. verdigris. Mix them well together, and dissolve a portion in water as occasion requires. The work must be dipped in these compositions, applied to a proper heat to burn them off, and then quenched in water or vinegar.

Red.—(*a*) Mix in suitable proportions the electro-copper bath already described with one of the baths for electrogilding; or use an old bath in which a great many copper articles have been gilt, with an intense current of electricity. Yellow gilding may be made to pass to red, by heating it after it has been covered with a paste of copper acetate, cream of tartar, and common salt. Plunge the heated piece into weak sulphuric acid, and carefully scratch-brush afterwards.

(*b*) To 4 oz. melted yellow wax, add 1½ oz. red ochre in fine powder; 1½ oz. verdigris, calcined till it yields no fumes; and ½ oz. calcined borax. It is necessary to calcine the verdigris, or else, by the heat applied in burning the wax, the vinegar becomes so concentrated as to corrode the surface, and make it appear speckled.

Pink.—This kind of gilding is the

most difficult to obtain on account of the different tendency of the various metals to galvanic decomposition. Pink gilding, to be perfect, should present at the same time the red, yellow, and white shades, in such a manner that a practised eye will distinguish them. The articles are first gilt yellow by the pyrophosphate bath for dipping, or by the hot electro-bath. Then, without drying, but keeping them in fresh water, small packages are made weighing 1–2 oz. each; pass lightly through the mercurial solution, and then red gilt in an old and hot bath, where a great deal of copper has already been gilt, or in a new bath composed of 10 parts hot electro-gilding bath, and 3 to 4 parts of the first coppering solution, with battery. For imparting the whitish tint of articles gilt by stirring and of the gold alloy for jewellery, the red gilding is passed through a boiling and nearly exhausted bath of pyrophosphate, to which add $\frac{1}{10}$–$\frac{1}{30}$ of its volume of a silver bath, or simply a few drops of a concentrated solution of silver nitrate. In either case a blush of silver is deposited upon the red gilding. This gilding should be scratch-brushed or burnished, and may be chased, but the lustre soon disappears on account of the proportion of copper. To obtain the proper pink gilding, if the first deposit is unsatisfactory, plunge the articles for a few seconds into a mixture of 5 parts sulphuric to 1 of nitric acid. The copper and silver are dissolved, and the yellow gilding reappears, upon which the operation may be begun anew. Besides the variations of colour in gilding due to the dipping of the anodes more or less into the bath, and to the strength of the electric current, moving the articles about in the bath will at all times enable the operator to vary the colour of the deposit from pale straw yellow to a very dark red. The temperature of the solution likewise influences the colour of the deposit, the colour being lightest when the solution is cold, and gradually becoming darker as the temperature increases.

Yellow.—6 oz. saltpetre, 2 oz. copperas, 1 oz. white vitriol, and 1 oz. alum. If it be wanted redder, a small portion of blue vitriol must be added. These are to be well mixed, and dissolved in water as the colour is wanted.

Dead Lustre Gilding, equal in appearance to the best mercury gilding, is obtained—(*a*) With silver. An electro-silvered bath is prepared by dissolving in $2\frac{1}{5}$ gal. water, $5\frac{1}{4}$ oz. fused silver nitrate, and adding 9 oz. pure potassium cyanide; this at first produces an abundant precipitate, which soon dissolves. The filtered liquid is the silver bath, in which is steeped the zinc article previously coated with copper or brass. Under the influence of a proper electric current, the silver deposited is of a handsome frosted dead lustre appearance, and perfectly white. The object is then rapidly and thoroughly rinsed, and dipped into an electrogilding bath. The dead gilding by this process is very fine and silky, but is soon darkened by the sulphuretted hydrogen of the atmosphere and of gaslight, which sulphurises the silver through the thin film of gold.

(*b*) The galvanoplastic process is both more durable and more economical than that with silver. Add to the necessary quantity of water, $\frac{1}{10}$ its volume of sulphuric acid; in this dissolve as much copper sulphate as it will hold at the ordinary temperature. This solution will mark 20°–24° B., then add enough water to reduce its specific gravity to 16°–18° B. This galvanoplastic bath is generally held in large vessels of stoneware, slate, wood, or gutta-percha; and porous shells are immersed in it, filled with a weak solution of sulphuric acid and amalgamating salts. Plates or cylinders of zinc are put into these cells, and are connected by binding screws with one or more brass rods, which rest upon the sides of the trough, and support the articles which are to receive a dead lustre in this bath. The articles of zinc, previously coated with copper or brass, suspended from the rods, remain in the solution of copper sulphate until they have acquired a satisfactory dead lustre. A few seconds after the articles have been placed in the bath, withdraw and examine them carefully; should the previous coat of copper or brass be insufficient to resist the corroding action of the acid solution of copper sulphate, there is produced a muddy dark deposit, which is easily removed with the finger. Should this occur, the object must be scratch-brushed and placed again in the former alkaline baths of copper or brass, in order to increase the deposit which protects the zinc in the galvanoplastic bath. When the galvanoplastic dead lustre is successful, the deposit is perfectly regular, and of a pink shade which possesses great freshness. When it is irregular, marbled, crystalline, of a vinous or fire-red colour, and dull or earthy in appearance, these defects are due to the following causes: either the bath is in a bad state of conductability or of saturation; or the surface of the zincs is too large in proportion to that of the objects, and therefore too much electricity is given out; or the previous electro-deposits of copper or brass were insufficient or inferior in quality. The remedy for either of these inconveniences is easily found out, and only requires a little care and attention. The galvanoplastic dead lustre being satisfactory, two preliminary operations are needed to ensure the success of the gilding. They consist in rapidly passing the object, after rinsing, through a solution made of water, $2\frac{1}{5}$ gal.; nitrate of binoxide of mercury, $\frac{1}{3}$ oz.; sulphuric acid, $\frac{2}{3}$ oz.; then, after rinsing, place it in another solution composed of water, $2\frac{1}{5}$ gal.; potassium cyanide, 14 oz.; silver nitrate, $3\frac{1}{2}$ oz. The object acquires a slightly white tinge in this liquor, and is again rinsed in fresh water, before being put into the following gilding bath:—Distilled water, $2\frac{1}{5}$ gal.; soda phosphate, 21 oz.; soda bisulphite, $3\frac{1}{2}$ oz.; potassium cyanide, pure, $\frac{1}{3}$ oz.; gold chloride, neutral, $\frac{2}{3}$ oz. The mode of preparation of this bath is given in the recipe for hot gilding bath. This bath should be nearly boiling, and worked with an intense galvanic current. The anode is a platinum wire, which, more or less immersed in the liquor, allows of the regulation of the amount of electricity according to the volume, weight, and surface of the object to be gilt. This gilding requires an energetic electric action at the beginning; this is obtained by steeping the platinum wire deeply in the liquid to have the entire surface of the piece covered instantaneously; as the thickness of the deposit increases, the anode is gradually removed from the bath until it only dips in a little. The gilding by this method has a remarkable freshness of tone. Before using the bath with battery, the zinc articles may be passed through a preparing bath; this is the same as a gold bath for dipping. Or the gilding may be done in two operations. After having deposited about half of the gold intended for the object, remove it from the bath, wash, pass again through the mercurial solution, and replace in the gold bath for finishing the gilding. After gilding, the articles are rinsed in clear boiling water for a few seconds to remove any saline matters; they are then dried in the stove, or in warm saw-dust of fir-wood. All friction should be carefully avoided, so as not to scratch the dead lustre. When parts of this gilding are burnished, their colour is green if the frosted surface has been obtained in the silver bath, and red if the galvanoplastic bath has been employed. These inconveniences are remedied by dipping the burnished article, for a short time, into the gold bath; this last deposit of gold must be so thin as not sensibly to impair the brightness of the burnished parts. Dead lustre electrogilding upon zinc will only suit such objects as have no friction to bear, and which are not often handled; it is especially useful for clocks and similar articles, which remain under glass. The dead lustre gilding here described can be applied to all metals and alloys, provided that those corroded by the solution of copper sulphate be previously coated with copper or brass; these previous coatings are always desirable, as they prevent the crystalline and irregular deposits often formed upon metals which are not corroded by the bath of copper sulphate. The galvanoplastic dead lustre upon copper is much finer when the pieces have been previously covered with copper or brass in the alkaline baths. Faded gildings may be renovated by dipping them into a weak tepid solution of potassium cyanide, and afterwards into very dilute nitric or sulphuric acid. Imperfect gildings may be removed by inverting the poles in a solution of cyanides, connecting the gilt articles with the positive pole (carbon or copper), and the négative pole (zinc), with the anode which becomes gilt. This process is employed for removing the gold from articles of iron, steel, and silver, which cannot be submitted to the ungilding bath. Silver, copper, and brass may also be removed by similar processes.

Ormolu.—This operation consists in smearing, by means of a brush, the gilt and scratch-brushed objects with a thin paste of potash nitrate, alum, and iron oxide, which have been well mixed and ground under the muller, and to which has been added a solution of saffron, annatto, or any colouring substance, according to the shade desired. If the gilding is strong and thick, the objects are heated until the previous coating curls over at the approach of a wet finger. If the gilding is a mere film, the mixture is simply allowed to stand upon the articles for a few minutes. In either case, the whole is rapidly washed in warm water holding in suspension a certain quantity of the materials for ormolu; they are then rapidly dried, when they appear of a darker shade; remove any portions too much coloured, by striking them vertically with a brush having long bristles. If the tint does not appear satisfactory, commence the operation afresh, after washing off the ormolu in dilute sulphuric acid.

Flowers and Insects.—At a recent meeting of the Physical Society, Berlin, Prof. Christiani exhibited as samples of a new method of preservation a series of organic bodies coated galvanoplastically. A mulberry leaf, a crab, a butterfly, a beetle, the brain of a rabbit, a rose-bud, and other objects, were plated with silver, gold, or copper, and showed all details of their outer form, down to the finest shadings. As to the process, it was stated that the objects to be preserved, being put into a solution of silver nitrate in alcohol, then dried and treated with sulphuretted and phosphuretted hydrogen, form good conductors, which, brought in the usual way into the galvanoplastic bath, can be coated with any desired thickness of a metallic deposit.

Glass and Porcelain.—(*a*) Sulphur is dissolved in oil of spike lavender until it has a semi-liquid consistence; this is mixed with an etherial solution of gold chloride, and the mixture is evaporated to the consistence of paint. The surface to be gilt is then covered with the mixture and the object is carefully heated in a muffle, whereby the volatile substances are expelled, and the metallic gold is fastened upon the glass or porcelain. The surface, thus metallised, is afterwards plated in the usual manner with solution of gold, and with the aid of a galvanic battery.

(*b*) Mix first in a crystal mortar, and then between a muller and a ground plate glass, neutral platinum chloride with rectified essence of lavender, so as to form a thin syrup, which is applied with a brush in very thin layers upon the object. After drying, heat in a muffle up to a dark red; this temperature reduces the platinum to the metallic state; it then appears with a perfect polish. After cooling, pass the whole object through aquafortis, which is without action upon the platinum, but destroys the impurities which may tarnish its surface. Rinse in plenty of water, wrap the object with a few turns of fine brass wire, having numerous points of contact with the platinised places, and dip into the gold bath. After a few minutes, the platinum is covered with gold which has the same adherence and polish. Rub the gold with chamois leather; this method dispenses with burnishing, which is costly, and often impracticable in the deeply indented parts. If the gilding is too red, add to the bath a few drops of a solution of double cyanide of potassium and silver (liquor for silver electroplating). This method is preferable to that of baths with separate battery; the gilding has a bright instead of a dead lustre, and its adherence is greater.

Silver by Dipping.—The silver articles, previously cleansed and scratch-brushed, are boiled for about ½ hour in the gold bath of pyrophosphate, to which add a few drops of sulphurous acid, or, preferably, hydrocyanic acid, in excess of the quantity needed by the primitive bath. This gilding is very fine, but without firmness. The deposit is rendered more rapid and thicker when the silver articles are stirred with a rod of copper, zinc, or brass.

Preparing Silver Parts.—Marks of the file are obliterated by a rubbing upon a wet stone, and lastly upon an oilstone. Any oil or grease is removed by boiling the parts for a few minutes in a solution made of 100 parts water and 10 of caustic soda or potash; rinse in clean water, which should wet them entirely if all the oil has been removed. The articles are threaded upon a brass wire; cleanse them rapidly in the compound acids for a bright lustre, and dry them carefully in white wood saw-dust. The pieces are fastened upon the even side of a block of cork by brass pins with flat heads. The parts are then thoroughly rubbed over with a brush, entirely free from grease, and charged with a paste of water and very fine pumice powder. Move the brush in circles, in order not to rub one side more than the other; thoroughly rinse in clean water, and no particle of pumice should remain upon the pieces, or the cork. Next place the cork and the pieces in a weak mercurial solution, which very slightly whitens the copper, composed of—water, 2⅕ gal., nitrate of binoxide of mercury, $\frac{1}{14}$ oz., sulphuric acid, $\frac{1}{7}$ oz. The pieces are passed quickly through the solution, and then rinsed. This operation gives strength to the graining which, without it, possesses no adherence.

Silver Powder.—Silver powder is obtained by immersing cleansed copper plates in a very dilute solution of silver nitrate made with distilled water. The more dilute the solution is, the finer is the precipitate of silver upon the copper, and the more easily it is removed. In a glass or porcelain vessel, ⅔ oz. crystallised silver nitrate are dissolved in 2⅕ gal. distilled water, and 5 or 6 bands of cleansed copper ¾ in. wide are placed in it. These bands should be long enough to allow of a portion being above the liquid. The whole is kept in a dark place for 24 hours, and now and then stirred with the copper bands. This motion is sufficient to loosen the deposited silver, and present fresh copper surfaces to the action of the liquor. When no more silver deposits on the copper, the operation is completed, and there remains a blue solution of copper nitrate. The silver powder is washed by decantation, or upon a filter, until there remains nothing of the copper solution. It is then carefully dried, avoiding contact with hard bodies. Nuremberg powder is produced by grinding a mixture of honey and silver foil upon a ground-glass plate with a muller until the proper fineness is obtained. The silver is separated by dissolving the honey in boiling water, and washing the deposited metal in a filter, until there is no remaining trace of honey. The silver is then carefully dried at a gentle heat.

Steel.—(*a*) Dissolve any quantity of gold or platinum in nitro-muriatic acid, until no effervescence is occasioned by the application of heat. Evaporate the solution thus formed to dryness in a gentle heat, and redissolve the dry mass in as little water as possible; next take an instrument which is used by chemists for dropping liquids, known by the name of a separating funnel, having a pear-shaped body, tapering to a fine point, and a neck capable of being stopped with the finger or a cork; fill it with the liquid about one quarter part; and the other three parts must be filled with the very best sulphuric ether. If this is rightly managed, the two liquids will not mix. Then place the tube in a horizontal position, and gently turn it round with the finger and thumb. The ether will very soon be impregnated with the platinum or gold, which may be known by its change of colour. Replace it in a perpendicular position, and let it rest for 24 hours, having first stopped the upper orifice with a small cork. The liquid will then be divided into two parts; the darker coloured being underneath. To separate them, take out the cork, and let the dark liquid flow out; when it has disappeared, stop the tube immediately with the cork; and what remains in the tube is the gilding liquid. Let it be put into a bottle, and tightly corked. When an article is to be gilded, a vessel of glass or unglazed ware must be provided, of just sufficient size to admit the article; it must then be filled with the gilding liquid, nearly to the top. The steel must be very highly polished, and entirely free from rust or grease. A basin, full of clean water, must be ready at hand, the article is immersed in the gilding liquid, and quickly removed; then quickly plunged into the water, and well rinsed; next dried with blotting paper, and placed in a temperature of 150° F. till it be completely heated throughout; it may then be polished with rouge and a soft leather, or be burnished. Pure gold must be employed. The ethereal solution may also be concentrated by gentle evaporation. Care must be taken not to wipe the steel until the heat has been applied. This gilding is an effectual protection against rust, and is very ornamental.

(*b*) Make a solution of 8 oz. nitre and common salt, with 5 oz. crude alum in a sufficient quantity of water; dissolve 1 oz. gold thinly plated and cut; and afterwards evaporate to dryness. Digest the residuum in rectified spirit of wine or ether, which will perfectly abstract the gold. The iron is to be brushed over with this solution, and becomes immediately gilt.

Watch Parts.—In gilding small articles for watchmakers, gold is seldom directly applied upon the copper; there is generally a preliminary operation, called graining, by which a grained and slightly dead appearance is given to the articles.

Graining.—A thin paste made of one of the graining powders and water is spread by means of a spatula upon the watch parts held upon the cork. The cork itself is placed upon an earthenware dish, to which a rotating movement is imparted by the left hand. An oval brush with close bristles, held in the right hand, rubs the watch parts in every direction, but always with a rotary motion. A new quantity of the paste is added two or three times, and rubbed in the manner indicated. The more the brush and the cork are turned the rounder becomes the grain, which is a good quality; and the more paste added the larger the grain. When the desired grain is obtained, the pieces are washed and then scratch-brushed. The wire brushes employed, which usually come from Nuremberg, are made of brass wires as fine as hair, very stiff and springy. It is necessary to anneal them upon an even fire to different degrees; one soft, or half annealed, for the first operation or uncovering the grain; one harder, for bringing up the lustre; and one very soft, or fully annealed, used before gilding for removing any marks which may have been made by the preceding tool, and for scratch-brushing after the gilding, which, like the graining, must be done by giving a rotary motion to the tool. Decoctions of liquorice or saponaire are employed in this operation.

Graining Powders. — (*a*) Silver in impalpable powder, 1 oz.; cream of tartar, finely pulverised and passed through a silk sieve, 10 oz.; common salt, pulverised and sifted as above, 2 lb.

(*b*) Silver powder, 1 oz.; cream of tartar, 4–5 oz.; common salt, white and clean, 13 oz.

(*c*) Silver powder, 1 oz.; cream of tartar, 3 oz.; common salt, white and clean, 2 lb.

All these substances should be as pure as possible, and perfectly dry. Cream of tartar is generally dry · common salt often needs, before or after it has been pulverised, a thorough drying in a porcelain dish, in which it is kept stirred with a glass rod. The mixture of the three substances must be thorough, and effected at a moderate and protracted heat. The graining is the coarser the more common salt there is in the mixture; and it is the finer and more condensed as the proportion of cream of tartar is greater, but it is then more difficult to scratch-brush.

Resists.—(*a*) If it happens that the same watch part is composed of copper and steel, this latter metal requires to be preserved against the action of the cleansing acids and of the graining mixture, by a composition called resist. This consists in covering the pinions and other steel parts with a fatty composition, which is sufficiently hard to resist the tearing action of the bristle and wire brushes, and insoluble in the alkalies of the gilding bath. Yellow wax, 2 oz.; translucent colophony, $3\frac{1}{3}$ oz.; extra fine red sealing-wax, $1\frac{1}{3}$ oz.; impalpable iron peroxide or polishing rouge, 1 oz. Melt the colophony and sealing-wax in a porcelain dish upon a water bath, and afterwards add the yellow wax. When the whole is thoroughly fluid, gradually add the rouge, and stir with a wooden or glass rod. Withdraw the heat, but continue the stirring until the mixture becomes solid, otherwise all the iron oxide will fall to the bottom of the mixture. The flat parts to receive this resist are slightly heated, and then covered with the mixture, which melts and is easily spread. For covering steel pinions, employ a small gouge of copper or brass fixed to a wooden handle. The metallic part of the gouge is heated upon an alcohol lamp, and a small quantity of resist is taken with it. The composition soon melts, and, by turning the tool around the steel pinion, this becomes coated. Use a scratch-brush with long wires, as their flexibility prevents the removal of the composition. When the resist is to be removed after gilding, place the parts in warm oil or tepid turpentine, then in a very hot soap-water or alkaline solution, and, lastly, in fresh water. Scratch-brush and dry in warm saw-dust of white wood. The holes of the pinions are cleaned and polished with small pieces of very soft white wood, the friction of which is sufficient to restore the primitive lustre. The gilding of parts composed of copper and steel requires the greatest care, as the slightest rust destroys their future usefulness. Should some gold deposit upon the steel, it should be removed by rubbing with a piece of wood and impalpable pumice-dust, tin putty, or rouge.

(*b*) When it is desired to obtain gildings of several colours upon the same object, resists, generally made of some kind of varnish, are used. After having gilt an article of a uniform red or green colour, it is covered with a fat varnish, made drying by the addition of lead chromate, at those places which are to resist the action of the new bath. By means of resists and successive baths, several different shades can be obtained upon the same object. The resist varnishes are applied with a brush or pencil, and should be thoroughly dried in a stove before placing the object in another solution. These varnishes may be coloured with various oxides or coloured salts, in order to facilitate their use upon those places which should be sharply marked; lead chromate and artificial ultramarine blue are well suited for the purpose. Resist varnishes are also used for preserving the reverse parts of articles which have to receive the gilding only on the front. When the operation is finished, the resist is easily removed by washing, first with essence of turpentine, gasoline, benzine, or benzole, and then with alcohol; when benzole is used, it is sufficient to wash the article in boiling water, and then to dry it in warm saw-dust of fir-wood. It comes out perfectly clean. This is not always the case with rectified turpentine, and it may be necessary to plunge the object into a hot alkaline lye, then to rinse and dry it in warm saw-dust.

By Cements.—Wood, leather, paper, and similar substances, are gilt by fastening on leaves of gold by means of some cement. The necessary materials are a cushion, knife, and tip, a large, short and thick camel-hair brush, cotton-wool, and oil and japanners' size. Gold leaf is sold in books of 25 leaves, each about 3 in. square. It is reckoned by the hundred, that is, the contents of four books, and gilders calculate a work to require so many hundreds, not so many books. There are 13 varieties of tint, ranging from a deep orange-red down to a white approximating silver. The cushion is a piece of wood about 8 in. by 5, covered first with baize, and then with buff leather tightly stretched. At one end there is a raised edge or screen of parchment, which turns partly round the sides. This is to prevent the leaves being blown away by any chance wind. Underneath, the cushion has two, and sometimes three small loops of leather, one for inserting the thumb to hold it by, the others for sticking the knife and camel-hair brush in. The knife for cutting the gold leaf has a long flexible blade, which should not be too sharp, set in a light handle like a palette knife. The knife must be always kept clean and bright. The tip is a large flat brush for taking up and placing the gold leaf. It is made of very long squirrel-hair, set thinly between the flat pieces of card. Cotton-wool and the thick camel-hair brush are used for dabbing down the gold and removing superfluous pieces. There are two kinds of gold size, fat oil and japanners' size. The former is the more durable and brilliant, so that japanners' size should never be employed except for mending small places and imperfections, or where time is of great importance. The gold from which gold leaf is made must be very pure; it is hammered out, after it has been rolled as thin as paper, by being put between the leaves of a book of parchment and extremely thin skins, called gold-beaters' skin; the book is then laid upon a block of marble, and beaten with a heavy hammer. When the leaves of gold are extended to the full size of the book, they are divided, and each portion is placed between the leaves of another book, which is hammered as before. This process is continued till the requisite thinness is acquired. Pale leaf gold has a greenish-yellow colour, and is an alloy of gold with silver. Dutch gold is copper leaf coloured yellow by the fumes of zinc. It is much cheaper than true gold leaf, and is very useful where large quantities of gilding are wanted in places where it can be defended from the weather, by being covered with varnish; it changes colour if exposed to moisture. Silver leaf is prepared in the same manner as that of gold, but is liable to tarnish, except it is well secured by varnish. I covered with a transparent yellow varnish, it has much the appearance of gold.

Gold Size.—Yellow ochre, 1 part; copal varnish, 2; linseed oil, 3; turpentine, 4; boiled oil, 5. Mix. The ochre must be reduced to the finest powder, and ground with a little of the oil before mixing.

Bronzing Gold-Size is japanners' gold size kept till very bright and tough from age, and then heated up and mixed with 1 gal. very old carriage varnish to 9 gal. gold size. This is used for laying on bronze and also gold, by writers, grainers, japanners, and gilders. The greater the proportion of carriage varnish, the slower it will dry. Some paper-stainers like it to dry quicker than others, and writers and grainers like it to dry quicker than gilders and japanners.

Fat-oil Gold-Size is made by grinding good Oxford ochre very fine in old fat linseed oil; when ground as stiff as possible, it ought to be kept for several years before it is used; the longer it is kept the better it becomes, as it acquires a rich mellow fatness. When this size is to be applied to work, take as much as is necessary, and mix it up with a little good fat boiled oil to a proper consistence, neither too stiff nor too fluid; then apply the size to the ground, laying it very regularly and rather fully, yet not so as to run or fall into wrinkles. Gilding with oil size is suitable for large picture or looking-glass frames, figured or lettered signboards, clock faces, and various articles exposed to the weather, where a great breadth of gilt surface is required, as it possesses more durability and boldness than any other kind of gilding, particularly when the gilding is varnished before it becomes foul. When it is necessary to revarnish old gilding in oil, such work ought always to be well cleaned from dust, grease, or any incrustation which covers the surface, otherwise the varnish will not dry off hard, but will remain cloudy and tacky, so as readily to retain dust and flies.

Various methods are employed by painters and gilders to clean old gilt work. Some wash the work well with a brush or sponge, which is sufficient in cases where the ground is firm, hard, and of a metallic colour; but where the grounds are absorbent, with gold letters, simply washing with water is in general insufficient. In such cases, employ an alkaline lye, made by dissolving 2 oz. pearlash in 3 pints water; then wet the work over with a brush or sponge dipped in the lye; let it remain some time, afterwards, with the sponge and clean water, wash off a part to see if the surface or gilding is properly clean, when it must be thoroughly washed with plenty of pure water, and wiped dry with a soft cloth or silk handkerchief. Oil of vitriol and water mixed until its acidity is equal to that of vinegar, is very cleansing, but requires considerable practice to apply it equally to the work, and it must not remain on too long, otherwise it will not only remove the dirt, but also the paint and gilding; it requires to be used with caution, frequently applying the sponge and clear water, in order to discover whether the surface is clean. When it is well washed and wiped dry, let the work stand to dry, and afterwards apply one or two coats of copal varnish. In revarnishing old work exposed to the weather, it is best to clean it over-night, and if the weather is fine next morning, and no appearance of rain, high wind, or dust, apply the varnish about sunrise, when the warmth of the sun will cause it to flow, set, and dry quickly and hard.

Flock Gold-Size.—Put 12 gal. linseed oil into the iron set-pot; as soon as it has boiled 2 hours, gradually introduce 12 lb. litharge. Continue the boiling very moderately for 6 hours; let it remain until next morning, then bring it to simmer, and run 10 lb. gum animi and 2 gal. oil. When these two runs of gum are poured into the iron pot, put in 7 lb. Burgundy pitch; continue the boiling, and keep ladling it down, as directed for the best gold size, boil it moderately strong, but not over-strong, and when right, mix it with 30 gal. turpentine, or more if required; this should be left a little thicker and stronger than japanners' gold size, as it is used for paper-stainers to lay their flock on, and ought to dry slowly in 1 hour.

Gold Powder for Gilding. — Gold powder may be prepared in three ways. (*a*) Put into an earthen mortar some gold leaf, with a little honey, or thick gum-water, and grind the mixture till the gold leaf is reduced to extremely minute particles. When this is done, a little warm water will wash out the honey or gum, leaving the gold behind in a powdered state.

(*b*) Dissolve the pure gold, or the leaf, in nitro-muriatic acid, and then precipitate it by a piece of copper, or by a solution of iron sulphate. The precipitate, if by copper, must be digested in distilled vinegar, and then washed, by pouring water over it repeatedly, and dried. This precipitate will be in the form of very fine powder; it works better and is more easily burnished than gold leaf ground with honey as above.

(*c*) The best method of preparing gold powder is by heating a prepared amalgam of gold, in an open clean crucible, and continuing the strong heat, until the whole of the mercury is evaporated; at the same time constantly stirring the amalgam with a glass rod. When the mercury has completely left the gold, the remaining powder is ground in a Wedgwood mortar with a little water, and afterwards dried. It is then fit for use. Although the last mode of operating has been here given, the operator cannot be too much reminded of the danger attending the sublimation of mercury. In the small way here described, it is impossible to operate without danger; it is therefore better to prepare it according to the former directions than to risk the health by the latter.

Burnished, or Water Gilding, will not bear being wetted, and is only fit for work to be always kept within doors. For this gilding the wood is first covered with 4 or 5 coats of whiting and size; and that the gilding should be perfect, it is necessary that there should be a sufficient body of whiting. When these are dry, they are laid over with a coat of gold size, made of Armenian bole, a little wax, and some parchment size. When the size is dry, a portion of the surface is wetted plentifully with clear water and a soft brush, and a leaf of gold is applied, so as almost to float on the water, when it instantly settles down and adheres to the size. Great care must be taken not to suffer any of the water to come over the gold, or a stain will be produced. When the whole is covered with gold leaf, the effect is what is called matt, or dead gold, and is the natural colour of gold not burnished. Such parts as are required to be burnished are rubbed over with an agate burnishing tool. Ornaments executed partly matt, and partly burnished, have a very rich effect, which is seen in most picture frames. As already stated, burnished gilding cannot be cleaned with water, though oil gold may; but the matt portion of water gilding is so like oil gold, as not to be distinguished by an inexperienced eye; and it may be very desirable to know, in that case, by which of the two processes it has been executed, with a view to cleaning it when soiled by flies or otherwise. This may be ascertained by observing in some crack or crevice whether the gold is laid on a coat of whiting; and if there is no other method, a small scratch with a knife may be made in some unimportant part to ascertain the fact. On account of the impossibility of washing water gilding without injury, it is necessary to take great care to protect it from flies, or other causes of soiling it, by covering it over with very fine net. Frames executed in water gilding are sometimes required to be regilt; this cannot be done without taking off the whole of the whiting, and commencing the process again, which is expensive. When this is done, the frames may be either regilt in the water or in the oil manner; and as the latter is much the cheaper, it is sometimes preferred, although it cannot be burnished.

Japanners' Gilding is where ornaments are drawn in gold upon japanned work, and is often seen in folding screens and cabinets. The ornaments are formed by a camel-hair pencil, with japanners' gold size, made by boiling linseed oil with gum animi, and a little vermilion. When the size is nearly dry, gold powder or gold leaf is applied. In all cases where gold has been fixed on by means of linseed oil, it will bear being washed without coming of.

Oil Gilding on Wood.—The gilding on wood, called oil gold, cannot be burnished, and is always of the natural colour of unwrought gold. It has the advantage that it may be washed and cleaned with water, which burnished gold never can. It is often used for picture frames, parts of furniture, and mouldings of apartments; as it stands the weather, it is also employed for outdoor work. The surface to be gilded should first of all be rubbed smooth, if stone with pumice, if wood with Dutch rushes, if a very bright level effect is desired. After this it should have its priming of glue size, and two coats of oil paint and one of flatting. To enrich the colour of the gold, these last may be laid down in red or yellow. White, however, is usually preferred, as the darker colour renders any imperfection in the gold-sizing more difficult to detect. When the last coat of paint is thoroughly dry, rub it over with wash leather, to render it smooth and free from dust or grit. If there are any patterns or figures which are to be left ungilded, they should be lightly pounced over with white to prevent the gold leaf adhering to them. Another way is to paint them over with the white of egg diluted with water. If any gold sticks to this, it can be easily washed or wiped off with a moistened handkerchief. When all is ready for sizing, strain sufficient size through muslin, and put some out on the palette, adding to it enough ochre or vermilion, mixed with oil alone, to colour. Then with a stiff hog-hair tool commence painting it on the surface, taking care to lay it on smoothly, and not too thick. If put on too thickly it runs, and leaves wrinkles in the gilding. Size always from left to right, beginning at the top of the surface, and working downwards. Move the brush lightly and firmly, mapping out the surface to be sized into several squares, and finishing and cross hatching each before proceeding onwards. If there are patterns to be left ungilded, carefully trace round their outline first with a sable pencil, and then fill in the interstices. When the whole surface is covered with size, give it a thorough inspection to make sure there is no faulty portion, and if there is, delicately touch in the size with a small pencil. When very perfect gilding is required, it should be sized twice, the first coat being allowed to dry thoroughly before the second is applied. In carved work, be careful to dip the brush down into the hollows of the carving. It is a good plan to size over night, so as to gild in the morning. But all size does not dry alike, sometimes taking 12 to 24 or 30 hours before it is ready for the gold leaf; in damp weather or positions, always more than in dry. The readiness of the size can only be ascertained by the touch. If on being touched by the finger the surface daubs or comes off, it is not ready, and must be left; if it feels clammy and sticky, it is sufficiently matured. If too dry it must be sized again. The books of gold leaf should always be placed before a fire ½ hour previous to use, in order to thoroughly dry the gold and make it more manageable. When all is ready, shake out several leaves upon the gold cushion, and blow them towards the parchment screen. Then carefully raise one leaf with the blade of the knife, and place it on the cushion, gently breathing on it to flatten it out. If it cockles up, work it about with the knife-blade until it lies flat. Then replace the knife in its loop under the cushion, and taking the tip, pass it lightly over your hair, thus acquiring sufficient greasiness to enable the gold to stick to it. Lay the hairy portion of the tip upon the gold leaf, and then raising it, apply it to the sized surface. As in sizing, work from left to right, and be specially careful to let each leaf overlap slightly, so as to avoid gaps and spaces. Lay on whole leaves as far as the space allows, and then proceed to gild the curves and corners which need smaller pieces. Place a leaf flat and smooth on the cushion, and then taking the knife in the right hand, draw the edge easily and evenly along it with a gentle pressure. Divide the leaf into as many pieces as required, and lay on as before. When the ground is complete, give a very careful inspection to make sure there are no portions ungilt, however small, and mend them at once. Next take a piece of cotton wool, and gently dab or press the gold down all over, finally brushing off the superfluous pieces either with cotton-wool or the camel-hair brush. It is a good plan to stipple the gold with a large stiff hog-hair tool, quite dry and clean, as this gradually softens and removes the marks of joining and other little imperfections. Finally smooth the gold with a clean piece of wash-leather, and it is completed.

With regard to gilding with japanners' size, the same instructions apply, except as to the time necessary to wait between sizing and gilding. If japanners' size is used pure, it will be ready in 20–30 minutes, but better gilding can be made by mixing one-third oil size with two-thirds japanners' size. This will be ready in about 2–4 hours from the time of putting on. When all the gilding is finished, dilute one-third very clean and pure parchment size in two-thirds water, and brush it all over the surface of the gold to enrich and preserve it. If it is necessary to gild in a position much exposed to touch, as the base of a pillar, or string-courses, it is as well to give the gold a coat of mastic varnish thinned with turpentine. There are various processes which tend to enrich and vary the effect of gilding. Glazings of transparent colour are sometimes applied for the purpose of deadening its lustre. Raw sienna passed thinly over a sheet of gold gives it a leathery appearance. A good effect may be produced by stencilling a small diaper in umber, sienna, or Indian red, over gold, especially if there is foliage or arabesque work upon the gilding, as the small diaper affords an agreeable relief. This is the easiest mode of gilding; any other metallic leaves may be applied in a similar manner.

Glass and Porcelain.—(*a*) Drinking and other glasses are sometimes gilt on their edges. This is done either by an adhesive varnish or by heat. The varnish is prepared by dissolving in boiled linseed oil an equal weight either of copal or amber. This is diluted by a proper quantity of oil of turpentine, so as to be applied as thin as possible to the parts of the glass intended to be gilt. When this is done, which will be in about 24 hours, the glass is to be placed in a stove, till it is so warm as almost to burn the fingers when handled. At this temperature the varnish will become adhesive, and a piece of leaf gold, applied in the usual way, will immediately stick. Sweep off the superfluous portions of the leaf, and when quite cold it may be burnished, taking care to interpose a piece of very thin India paper between the gold and the burnisher. If the varnish is very good, this is the best method of gilding glass, as the gold is thus fixed on more evenly than in any other way.

(*b*) It often happens when the varnish is but indifferent, that by repeated washing the gold wears off; on this account the practice of burning it in is sometimes had recourse to. For this purpose, some gold powder is ground with borax, and in this state applied to the clean surface of the glass by a camel-hair pencil; when quite dry, the glass is put into a stove heated to about the temperature of an annealing oven: the gum burns off, and the borax, by vitrifying, cements the gold with great firmness to the glass; after which it may be burnished. The gilding upon porcelain is in like manner fixed by heat and the use of borax.

(*c*) The glass must be thoroughly cleaned and polished. A size must be prepared as follows:—Isinglass 1 oz., dissolve in just sufficient water to cover it; when dissolved, add 1 pint rectified spirit of wine, then increase the quantity to 1 qt. with water; keep tightly corked. Or, take best rum ½ pint, isinglass, ¼ oz. Dissolve the isinglass in the rum at a low temperature, then add ½ pint distilled water and filter through a piece of old linen. Place the glass flat on a perfectly level table, then with a clean brush flood the glass with the size to the depth of ⅛ in., raise the gold leaf with a tip and lay it flat on the size; it will almost instantly adhere to the glass; in 5 minutes afterwards place the glass endways at a slight angle against a wall, that the surplus size may drain off. Allow the glass to remain in that position for 24 hours, by that time it will be perfectly dry. Draw the pattern or letter on a piece of paper, and with a thick needle pierce holes on the lines at the distance of $\frac{1}{16}$ in. apart; place the pounced paper on the gold surface, then dust some powdered whiting well on the paper that it may penetrate the holes; remove the paper carefully, and there will remain a correct copy of the design on the gold. Now fill up the outlines of the design with oil gold-size in which has been ground some orange chrome, thin it with a little boiled oil and turpentine. When thoroughly dry, wash off the surplus gold with water and a piece of cotton-wool. Back the glass with any suitable colour.

(*d*) Burnished.—The gold used is the ordinary gold leaf. Procure some fine isinglass, and place about as much in a tea-cup as will cover a sixpenny piece, and then pour on it about half a cupful of boiling water, which will dissolve the isinglass. Before the water is cold add about as much spirits of wine as there is water in the cup; then strain the whole through a clean silk handkerchief, and the mordant is ready for use. The addition of the spirits of wine is most material, as without it the gilding cannot be satisfactorily accomplished. Whatever may be the design or lettering, it must first be set out on a sheet of white paper, and painted with Brunswick black, so that it can be seen on the reverse side. This paper with the writing reversed should be fixed at the edges or corners to the glass, the writing, of course, appearing backwards. The glass having been thoroughly cleansed and rubbed with a silk handkerchief, the gilding may be commenced, the gold leaf being laid on the reverse side to that to which the paper is attached. It is usual to place the glass in a slanting position on an easel, the lines of lettering not being horizontal, or reading from left to right, but perpendicular, reading from top to bottom. The mordant is put on with a large soft camel-hair pencil, and the gold leaf is lifted from the cushion and placed on the mordant with a tip, after having been cut to the required dimensions. If the line of writing is less than 3 in. high, it is advisable to gild the whole line, without paying any regard to the shapes of the letters, so that when the line is finished it will be a solid piece of gilding about the same height and length as the letters. The first piece of gold leaf should be placed at the beginning of the line, which is the top of the glass, and each succeeding piece below it, the different pieces just overlapping each other. It is necessary to be particular in this, for if the pieces of gold do not meet, the interstices will probably show when the work is completed, and will prevent the uniformity of burnish. For letters larger than 3 in. high, the gilding may be made to cover each letter, leaving the spaces between untouched. As soon as this part of the gilding has been completed, it should be left to dry in a warm room, or placed before the fire, in which case it will be dry in a few minutes. When the gilding is perfectly dry and bright, it should be rubbed over very gently with a piece of cotton-wool. This will heighten the burnish of the gold, and remove the loose pieces which do not adhere to the glass. After the gilding has been treated as described, a flat soft camel-hair brush charged with the isinglass size should be passed lightly over the work; but not worked too and fro, or it will remove the gold leaf. The size should be flowed on freely and rapidly, and if any small pieces have been omitted, no attempt should be made to retouch them while the size is wet. When it is dry, the gilding will resume its brightness. In order to complete the burnish of the gold, sometimes hot water is poured over the gilding, and this not only washes out any little specks which may appear on the front of the gold, but enhances its brilliancy considerably. The hotter the water poured over the work, the brighter does the gilding become, but care must be taken, as beyond certain degrees of heat the water will break the glass. The hot-water bath now is often dispensed with, and the size coated over the gilding is applied hot. This method is not quite so effective but it is much safer. The whole of the gilding has now to be repeated. A second layer of gold leaf over the first is necessary to ensure a satisfactory result. The second coat of gold is put on with the isinglass size, the same as the first; and as it dries, the gilding viewed from the front of the glass will present a rich and finished appearance. The loose pieces of gold should be removed as after the first coat, by means of cotton-wool gently rubbed over the work. Another coat of size made hot may now be applied, and the gilding is ready to be written upon. It is better to leave the gilding on for a day or two before writing upon it, because the isinglass does not get thoroughly hard, though to all appearance it is perfectly dry in an hour or two. If the gilding is left untouched for 2-3 months, the action of the spirits of wine will cause the gold leaf to adhere so firmly to the glass that it will be difficult to remove it by any amount of washing with water; whereas in the course of a few days after it is laid on, it may be readily removed by a damp sponge. There are several ways of transferring the outline of the writing to the gold. The most expeditious method is to rub some dry whiting over the front side of the writing, on the paper, place this over the gilding, face downwards, then go over the outline of the letters with a pointed stick or hard pencil. On removing the paper, it will be found that where the letters have been traced, the whiting has marked the gold. Having an outline of the writing or design, next paint the letters with a sable writing pencil, and the ordinary japan black used by coach painters. If on turning the glass round it should be seen that the japan black deadens the gilding or is perceptible in any way on the front of the glass, another coat of size should be passed over the gold to prevent the black from coming through the gold leaf. When the japan black is hard, the superfluous gold must be washed off with a sponge and warm water. When the japan is dry, the edges of the letters may be cut sharp and true by passing a small chisel along a straight edge, so as to trim the writing, and make the tops and bottoms perfectly regular. All the straight lines of the letters may be thus trimmed, but the curved ones must be perfected with a writing pencil. The softened coloured thicknesses added to the letters are painted with the ordinary oil colours thinned with boiled oil and turpentine, the latter being used sparingly. Three or more tints are generally mixed on the palette, with a separate pencil to each, and these are softened with a larger sable pencil, and the outer edges are cut up with a pointed stick guided by a straight edge, whilst the colour is wet, and the superfluous colour is wiped off with a piece of rag. By this means a sharpness of outline is obtained which the most skilful writer would fail to get by the mere use of the pencil. The shadow is put on as soon as the thickness is dry, and not being softened down, quick drying colours may be employed.

Leather.—In order to impress gilt figures, letters, and other marks upon leather, as on the covers of books and edgings for doors, the leather must first be dusted over with very finely-powdered dried white of egg, yellow rosin, or mastic gum, upon which lay a leaf of gold. The iron tools or stamps are now arranged on a rack before a clear fire, so as to be well heated, without becoming red hot. If the tools are letters, they have an alphabetical arrangement on the rack. Each letter or stamp must be tried as to its heat, by imprinting its mark on the raw side of a piece of waste leather. A little practice will enable one to judge of the heat. The tool is now to be pressed downwards on the gold leaf, which will, of course, be indented, and show the figure imprinted on it. The next letter or stamp is now taken and stamped in like manner, and so on with the others; taking care to keep the letters in an even line with each other, like those in a book. By this operation the rosin is melted; consequently, the gold adheres to the leather; the superfluous gold may then be rubbed off by a cloth, the gilded impressions remaining on the leather. The cloth alluded to should be slightly greasy, to retain the gold wiped off; the cloth will thus be soon completely loaded with the gold. When this is the case, these cloths are generally sold to the refiners, who burn them and recover the gold.

Paint. — The paint must first be thoroughly dry. The letters must be written on the paint with gold size, and allowed to get a little dry, or else the writing will appear dull. Now press the gold leaf on the size, and rub it down with a piece of cotton-wool. If by accident there is more than one thickness of gold it will appear dull.

Paper-hangings.—The part which is to show the gilt is first printed in common size mixed with a little water; when dry, rolled up and reprinted in gold size, and as it is being printed the piece is drawn out from the table into a trough, technically called a drum, and then the metal, which is Chinese bronze, is slightly laid over the surface, and the drum is tapped underneath with a common cane, which causes the metal to adhere to the gold size; it is then carefully drawn out of the drum and hung up till dry, then rolled up; to improve the appearance, the hangings are passed between two embossing rollers, which give the finishing touch.

Picture Frames.—Suppose that we have a plain picture frame; it is made by the joiner into a 12 ft. length of moulding, and in that state it passes into the hands of the gilder. He first gives it a priming of hot size and whiting, called thin white. The whiting employed by the gilder is not the same as that used for domestic purposes, but is finer and more free from grit. The size employed is prepared by the gilder from parchment or glove cuttings. The cuttings are well washed in water, and then boiled in a certain quantity of clean water, until the latter has a particular degree of adhesiveness, which can only be determined by experience; this is then poured off into a clean dry vessel, and allowed to cool. When about to be used, the grease at the top and the sediment at the bottom are cut off with a knife, the size is melted in an earthen pipkin, and a small quantity of finely-powdered whiting is mixed up with it. When the thin white is dry, all holes and irregularities in the moulding are filled up with putty. This putty is not the same as that employed by the glazier, but consists of whiting and size mixed to the consistence of putty. When the putty is dry, a coating of thick white is laid on with a brush. This thick white differs from the thin white only in having a larger proportion of dry whiting mixed with a given amount of size, the consistence attained being rather thicker than that of oil paint. When the first thick white is dry, another is laid on in the same manner, and, similarly, a third, a fourth, and a fifth, are laid on, all about equal in thickness, and each one being perfectly dry before the next is applied. As in laying on this large body of thick white, the fine squares, hollows, and fillets would be liable to be stopped up and lose all their clearness and sharpness, opening tools, consisting of crooks, chisels, and gouges, are drawn along the fine parts of the moulding, while the thick white is still wet; by which means the forms of the various mouldings are retained. This is still better effected by the double opening white, which consists of two thick whites; the one laid on almost immediately after the other, by which a thick soft coating covers the moulding. Hard stones, shaped to the forms of the mouldings, together with the opening tools before described, are to be worked over every part of the moulding, by which asperities are smoothed down, depressions filled up, and edges brought up nearly to their required sharpness. In this state the whiting on the moulding is $\frac{1}{16}$–$\frac{1}{12}$ in. thick. It is now trimmed at the back and edges by cutting off the whiting which had flowed over from the front, which prepares it for the process of smoothing. This is done by means of pieces of pumice and other stones, shaped so as to fit the various parts of the moulding. A sponge or soft brush is used to wet the moulding, and the stone which is to be used, being likewise wetted, is rubbed or worked to and fro along the moulding until that part is perfectly smooth. Another stone, fitting a different part, is then used in the same way; and so on, until every part of the length and breadth of the moulding has been worked over by the stones. The moulding, if the smoothing has been properly performed, now presents a smoothness of surface exceeding, and a keenness of the edge nearly equalling, that which the moulding presented when it left the hands of the joiner; but this must be attained without rubbing off too much of the whiting, since the whole beauty of the frame mainly depends on having a sufficient body or foundation of whiting. The brilliant burnishing on frames is, in a peculiar degree, dependent on the whiting which is first laid on the wood, and which, if deficient in quantity, cannot be adequately replaced by other means. The moulding, being thoroughly dried from the effects of the smoothing, is rubbed down with glass-paper or sand-paper, to take off any little asperities that may remain, and to make the whole perfectly smooth. It is now ready for the process of gold-sizing. The burnish gold-size used in this process is composed of ingredients exceedingly opposite in their nature, such as pipe-clay, red chalk, black-lead, suet, and bullock-blood. This diversity of ingredients is intended to produce different effects; one substance helps to give a brilliancy to the burnish, another to the mellowness and smoothness, and so on. The form in which the gilder purchases his burnish gold-size is that of a solid rather softer than butter. He first takes some very clear size, boiled purposely to a smaller degree of strength than the size for thick white, or, if already boiled, weakened by water. This size he melts in an earthen pipkin, but without making it very hot, and then mixes the gold size with the melted size by means of a clean brush, much in the same manner as a painter mixes his oil paint; the consistence to be about equal to that of cream. It is a source of some confusion that the same term, burnish gold-size, is applied to this creamy liquid, as to the thicker substance from which it is prepared; it is necessary to say mixed gold-size, or unmixed gold size, in order to indicate which is meant. This gold size is laid on the moulding either with a very soft hog-hair brush, or by a large camel-hair pencil, fixed in a swan quill. The gold size must be barely warm, and must be laid on with great care so as to leave it equally thick in every part, and obliterate the marks of the brush; upon the due observance of a medium between hot and cold, strong and weak, and thick and thin, in the gold size laid on, depends much of the beauty of the moulding when gilt. From 4 to 8 coats of this gold size are laid on the moulding, each one being perfectly dried before the next is applied. A soft, partially worn piece of glass-paper is occasionally used, to take off any little roughness that may exist. When a sufficient body of gold size is laid on, it is carefully washed with clean water, a soft sponge, and a piece of linen rag. This must be done with attention to the soft edges, which are very likely to lose the whole of their gold size, if care is not used; the object is to produce a perfectly smooth surface, especially in those parts which are to be matt gold. The test of good work is to produce the smoothest surface with the least loss of gold size. When the moulding is partially dry from this process, the matt parts are polished with a piece of woollen cloth, and the parts to be burnished receive another coating of gold size, laid on as smoothly as possible. The piece of moulding which is to be gilt is laid along the bench with one end higher than the other; and as the width of the moulding is broken up into several divisions, such as hollows and squares, it would be impossible to make a leaf of gold bend into all the various parts without breaking. The gilder learns by experience how many separate lays, as they are called, of gold will be required to cover the width of the moulding without the breaking of the gold into irregular fractures called spider-legs. In general, a deep hollow, or a depressed square, cannot be gilt at one lay, but must be covered with two strips of gold, laid side by side and meeting at the centre of the depression. When the gilder has made his decision as to the number of lays that will be required, he selects one lay, and proceeds with it through the whole length of the moulding before he begins another portion of the width. If the necessary lay be about $\frac{3}{4}$ or $\frac{7}{8}$ in. wide, he cuts the leaf which is spread out on his cushion into 4 strips; if it be about 1 in. wide, he cuts the leaf into 3, regulating the division of the leaf of gold according to the width of the lay. It is not often that a larger piece than half a leaf is used at once. The gilder has at hand a pan with clean water, and 2 or 3 camel-hair pencils of different sizes. With one of these pencils he wets a few inches of that part of the moulding which is to form his first lay, taking care not to wet much beyond that lay. The water is to be allowed to remain pretty full on the surface, after some of it has been imbibed by the gold size. The gilder then takes his tip in his right hand, and lays it on the slip of gold, which slightly adheres to the hairs; whence he places it on the moulding, with particular attention to straightness of direction. It frequently happens that the hairs of the tip will not take up the gold; in such case it is usual to rub the hairs between the cheek and the palm of the hand, by which their power of taking up the gold is increased. When the gold is laid on it is blown forcibly, to expel as much of the water as possible from beneath it, the dry camel-hair pencil being used to press down any parts which fail to adhere. Another portion is then wetted, and another piece laid on, lapping about $\frac{1}{8}$ in. over the end of the former piece. Thus the gilder proceeds, piece after piece, until the one lay is carried down the whole length of the moulding, he then proceeds with another lay joining the former. In doing this he has to observe that the water must be made to flow a little over the edge of the former lay, but not so as to wash it up, or break away the edge; the second lay must lap a little over the first, and therefore the water must likewise extend over the first lay. Thus he proceeds with all the lays into which he has found it necessary to divide the width of the moulding; every piece, lengthwise, lapping over the piece previously put on, and every lay lapping over the previous lay. The moulding is then set aside to dry. There is a particular state or degree of dryness, known only by experience, in which the moulding is is in a fit state for burnishing. The burnishers used by the gilder are either of flint or agate, generally the former; the steel burnishers employed by the jeweller would not do for the gilder.

Burnishers of different forms and sizes must be employed, in order to adapt them to the part of the work which is being burnished; they are generally crooked or curved near the end. When the burnishing is done, those parts which have not been burnished are weak sized, that is, they are wetted with water in which a very little clear piece of size has been melted; this helps to secure the gold. When dry, the gold is wiped carefully with a piece of soft cotton-wool, to remove rough or ragged edges of gold; and there are now visible a number of little breaks, holes, and faulty places in the gilding, arising from the impossibility of laying on the gold quite soundly and perfectly. These defective parts are repaired by the process of faulting, which consists of cutting up a leaf of gold into small pieces and laying them on the faulty places, previously wetted, with a camel-hair pencil. If the defective part is on the burnish, it is necessary to be careful not to wet any part but what is to be covered by the gold, as it will stain the burnished gold. When the faulting is dry, the gold is again carefully wiped, and finally wetted with finishing size. This is clear size of a certain degree of strength, laid on the matt parts with a pencil, and completes the process of gilding. When a glass frame is to be gilt, the joiner's work is generally quite completed before the gilder begins, and great care is required in whiting such frames, to prevent filling up the corners with whiting, and giving them a clumsy appearance. For this purpose, modelling tools, such as chisels, gouges, and crooks, are used to clear out the corners from time to time, and preserve the original sharpness and clearness of the several parts.

Composition for Moulding.—(*a*) The following is used by gilders;—Mix 14 lb. glue, 7 lb. rosin, $\frac{1}{2}$ lb. pitch, $2\frac{1}{2}$ pints linseed oil, 5 pints water, more or less according to the quantity required. Boil the whole together, well stirring until dissolved, add as much whiting as will render it of a hard consistency, then press it into a mould, which has been previously oiled with sweet oil. No more should be mixed than can be used before it becomes sensibly hard, as it will require steaming before it can be used again.

(*b*) Make a very clear glue with 3 parts Flanders glue and 1 part isinglass by dissolving the two kinds separately in a large quantity of water, and mix them together, after they have been strained through a piece of fine linen to separate the parts which could not be dissolved. The quantity of water cannot be fixed, because all kinds of glue are not homogeneous, so that some require more than others. The proper strength may be found by suffering the glue to become perfectly cold; it must then barely form a jelly. The glue is gently heated, then mixed with saw-dust sifted through a fine sieve. The moulds are then oiled with nut oil, and the glue is pressed into the mould, covered with a weighted board, and then set to dry near a stove. When the casting is dry, it is to be trimmed.

Burnished Gilt Frames.—When new burnished gilding requires varnishing, white hard spirit-varnish is used, or yellow gold lacquer. Old burnished work must be cleaned with great care. First remove the dust with a badger-hair brush; afterwards clean the gilding by passing a clean sponge dipped in gin and water, lightly over the surface, wiping off the moisture with a very soft dry sponge or silk handkerchief; then apply the varnish, and finish.

Cleaning Gilt Frames.—Gilt frames may be cleaned by simply washing them with a small sponge, wet with urine, hot spirits of wine, or oil of turpentine, not too wet, but sufficiently to take off the dirt and fly marks. They should not be afterwards wiped, but left to dry of themselves.

Re-gilding Frames. — (*a*) Take a sponge and some clean water, and wash the frame well; let it dry; procure some water-gold size; make some thin size from dry hide or parchment; mix enough warm with the gold size to enable you to work it on the frame with a camel-hair brush; give it two coats; when dry, rub it over with a piece of fine sand-paper; it will then be ready for gilding. When the frame is covered, rest it on its edge to drain; when perfectly dry, dip a pencil into water, and wipe the gold over with it; it will take the particles of gold off, and make it appear solid. For any parts not covered, take bits of leaf with a dry pencil, and lay on as before, then give the whole a coat of clear parchment size, brush the back edges over with ochre, and the frame is then ready.

(*b*) The tools required for the job are the following: a pint basin with a lip, two moderate sponges, and two small finger sponges, three fitches, one flat, $\frac{1}{4}$ in. wide, one round $\frac{1}{4}$ in., and one $\frac{3}{8}$ in. or $\frac{1}{2}$ in., round. We will count these three one set, for sizing. You will want another set for whiting, another for claying, one fitch for skewing, one small sash-tool for washing off, and one about 1 in. diameter for duster; a gilders' cushion, a gilders' tip, a camel-hair dabber, a gilders' knife, some fat pipe-clay, some prepared whiting, some plumbago, oil gold-size, crystal size, or parchment cuttings to make some, two agate burnishers, one round, about the diameter of a goose-quill, and one oval, larger, or about double the above on the broad part, and some composition made of glue, whiting, and linseed oil. The picture taken from the frame, dust well, and proceed to wash off with clean water, not letting your brush hold too much, to make your work too wet. When washed off let stand by for some time to get dry and steady. Now is your time to make all ornamental work good, or repairs. To work the compo you will need two pieces of brass wire, one about $\frac{1}{4}$ in. and one about $\frac{1}{8}$ in. full, bent in the shape of an *f*, the ends being flattened to form a kind of trowel in miniature, such as used by artists in clay modelling. Make your compo warm, and work it well, that it may not work lumpy. Having some hot glue, dab some upon the sore place, press your compo upon it; in a few minutes you may proceed to shape it to correspond to the rest of pattern. Having made all things ship-shape, that which is to be matt, i.e., the bottom of design, is to be laid down with gold size very sparingly, and after that has been gilded, if the prominent parts or that which is in relief is to be burnished, is to be sized and clayed; then, after being allowed to dry, another coat of weak size; this is allowed to dry. When you are about to lay the gold on, wet it with clean water. The oil gold-size will take 2–5 hours before it will be fit to receive the gold, and will depend, in a great measure, upon the weather. This oil gold-size is composed of prepared linseed-oil, very finely-ground litharge, and stone ochre. The cushion-knife and tip can be dispensed with, although these and the dabber are all held in the hands when laying on the gold by the professional. The cushion is a board about the dimensions of a half-sheet of note-paper, the back half of which is walled around with a piece of parchment about 2½ in. high; the floor of the cushion is wash-leather, as it is usually called, prepared with red chalk; on the under side is a strap to strap it upon your thumb, or the gilder's thumb of the left hand, the hooded or walled part projecting over back of the hand, the fingers being curled. The tip is placed between the second and third finger, and the knife between the little finger and next, and the dabber between the forefinger and thumb. He takes a book of gold and shakes out three or four leaves into the hood—pell-mell as it would seem to the uninitiated, places the book down in a safe place, takes the knife and picks up one of the leaves and tosses it about, gives it a puff of wind from his lips, and there it is spread out upon the cushion without a wrinkle in it. He then proceeds to carve it up into the shape or size pieces that he sees most convenient to cover his job. He then returns the knife to its proper place, and takes the tip, which is some long badger-hair between some card for a handle. He whisks the tip over the hair upon his head or down his whiskers, and applies it to a piece of the leaf gold; it instantly picks it up like a magnet. By these means he conveys and deposits the gold where required, replaces the tip, and takes the dabber and dabs it down. Some will dab with the dabber between the little finger and next upon the right hand with the dabbing part outside, and will pick up and dab and cover a frame in a few seconds. After covering (see that it is all covered), let stand for an hour or two, and skew off. That is done by the skewing-fitch; the tool is held between the thumb and forefinger of right hand, and pressed lightly down upon the gold, and a slight skewing or twisting action is given to it, and the fine gold or pounce liberated by the action is skewed by the same action into the interstices and angles of the pattern that the dabber could not get at. Continue this action with the powder under your brush, until you have gone around your frame; then skew your gold powder off on to a highly glazed piece of paper and preserve. When you commence gilding, the best plan is to spread a sheet of manilla paper under your work—this is a very highly glazed paper of a whitey-brown hue, and very tough; the parts to be burnished should have at least two coats of size and whiting and of clay before gold is laid on. Now for the dead and burnished work. Having washed and repaired mitres, &c., and set aside to steady or dry, have some No. 1 glass-paper and rub down with finger or cork rubber. Give one coat of parchment size and whiting; the size must not be too thick or thin, that it will not congeal at the ordinary temperature of the room or atmosphere. But the test of the thumb and finger is the best criterion to go by; if too thick, your work will peel off when placed in a warm room, or on a hot summer day. If new work, a coat of weak size first, next whiting and size; let dry and rub down. A second coat, dry and rub down, then a coat of clay, then drop down and go over with weak size, and set by to dry. When dry, see that there are no cracks or chance of its peeling off. Then, with clean water and soft brush lightly damp, and lay the gold on immediately after, and dab down. Let stand by to dry. The flat remaining dead, the hollow or bead may be burnished. The burnishers here mentioned are curved like a horn that you can get into a hollow, a quirk, or over a bead. When completed so far, you may either size or varnish. It is usual to size matt and ornamented work, and dead upon mouldings. It is a great protection against dust. If not sized, it would soon be smothered in dust, and no dusting or washing would remove it or improve it. Now for sizing: Take a clove of garlic about as thick as a quill, and finely grind up with a little water. Mix with a couple of table-spoonfuls, let settle and filter. Dissolve size in it and apply. This will lay the rough surface, and is said to protect it from that nuisance, fly-soils; but if you would like to varnish that, you may remove the fly-soils with impunity. Take ½ oz. gum-sandarac to ½ pint good spirits of wine, and in another small phial (about 1 oz.) put one pennyworth of saffron. When the former is dissolved and settled clear, pour off, and add some few drops of stain until of the desired colour; go over the gold with a coat of very weak size, and, when dry, varnish and turn upside-down to dry free from dust. To make the oil gold size—take, say, 1 lb. white-lead and red-lead, mix with ½ pint good raw linseed oil, pour about gill boiling water into it; when well mixed up let stand for a day, then add another ½ pint oil and well stir up twice a day (morning and night), and in a few days you will have a beautifully clear, fat oil, almost colourless; this must be mixed or ground up with stone ochre and litharge, not as a paint but as a stain, and to render it siccative; this may, when prepared, be kept some considerable time, without drying, in a jar or gallipot, if covered with a piece of paper, dressing the top with oil, but will dry in a very little time when put on very thin, as for gilding, subject to the state of the weather. It may be ready in an hour, and may not be fit in 5 hours. Deep, extra deep gold, is used for the purpose. If you prepare your own whiting, it must be well washed, and remain to allow the coarse to settle a few seconds, and then decanted into another jar to settle; finally, make a tray of a square of blotting-paper double, pinch up the corners, and put upon a Bath-brick; pour the water off as far you can, and the thick into the tray. The brick and paper will soon absorb the water, and your whiting, after the paper covers are taken off, will be free from grit, and may be placed in a jar or bottle fit for use. Your plumbago must be served the same, and your clay, and about 2 per cent. plumbago is mixed and washed with your clay, after being washed separate, and your clay is fit for use. By the Bath-brick the liquor is absorbed very readily, and preparations of this kind, and precipitates, filters, &c., reduced to a minimum of trouble. Your sponges you will find use for in case of swamping.

Pottery.—An air-tight kiln is required, which must be lime-washed every time it is used. On a small scale a retort would do well, made of Stourbridge clay, and fixed in brickwork, with access for drawing trials, bits of pitcher with a little gold on, drawn with tongs. Take ¼ oz. brown gold, ¼ oz. quicksilver, 10 gr. tin, 10 gr. white-lead, well pound together in Wedgwood mortar and pestle. Then grind on glass slab and muller, with a few drops of water, for several hours; add a drop of water as it dries, then repeat in turpentine, leaving it about the consistency of cream. It is then ready for use, or if kept for a day or two it will work better; it is laid on with a camel-hair pencil. Thin it with turpentine, as it soon dries, and should be kept covered when not in use. A little fat oil is added to make it work better. To make fat oil, evaporate turpentine to the consistency of treacle.

Signs or Letters.—The following method is adapted for working in the open air, when the ordinary process with the cushion is rendered difficult if there is much wind to blow the gold leaf about. Take a sheet of tissue paper and rub it over on one side only with a piece of white wax. This should be rubbed rather briskly over the surface of the tissue paper, placed on something flat, so that the wax is spread evenly throughout. The paper which has thus been rubbed will possess a certain sticky quality, scarcely perceptible to the touch, but sufficient to cause the gold-leaf to adhere to it. After a whole sheet of paper has been waxed as described, it should be cut into squares a little larger than the leaves of the book of gold. The gold leaf book must be opened and the waxed side of the tissue paper gently pressed upon the gold-leaf with the hand. On removing the paper the gold leaf will be found attached to it. The gold leaf being thus secured upon the tissue paper, is ready for use. It is evident that the difficulty experienced through the thinness of the gold is by this means to a great extent overcome. The tissue paper may be used over and over again. It is supposed that the letters to be gilded have been written in the most suitable material, and that they are ready to receive the gold leaf. Take up the tissue paper and place it with the gilded side to the letters, and having rubbed the back lightly with the hand, the gold will come off the paper and adhere firmly to the mordant with which the lettering has been written. By this method very little gold is wasted, as the tissue paper being semi-transparent, the gold leaf shows through it, and the operator can see where any portion of the gold adheres to the paper, and can accordingly place it on such portions of the work as it will best fit without an undue number of joinings, though by this process, if the gold leaf is good, not the slightest trace of joining is discernible. The gold leaf should be gently dabbed over with a pad of cotton-wool, which will smooth the surface of the gilt, and remove all superfluous pieces of gold leaf. As a newly-painted surface is sticky, if the gold leaf were to be applied to it, it would adhere to parts of the ground colour where the mordant had not touched and where the gold was not required. It is needful, therefore, before the letters or parts to be gilded are marked out, that the newly-painted surface should be dabbed over lightly with dry whiting; but care should be taken that the loose particles are dusted off by the gentle application of a silk handkerchief. If the ground is dark, this pouncing will so far lighten it, that the gilder will be able to distinguish any lines he may make with size, as the size will restore the ground to its original colour. But if the ground is light, the pouncing will not have this effect, and it becomes necessary to mix some kind of colour with the size to enable the gilder to make certain that he has thoroughly covered the portion to be gilded. For pouncing, put some powdered whiting in a small linen bag, tie it up tightly, and gently dab it over the parts to be pounced. The whiting is removed from the ground after the gold leaf is applied, by means of a damp chamois leather. The mordants for gilding are of different kinds. Picture-frame gilders generally use gilders' size, made of fat oil, in which yellow ochre has been ground. This is a good material for the sign-writer, but it is too thick for general adoption, especially in cold weather, when it is unmanageable with the sable pencil. In hot weather, however, it is not so thick, and may often be used with advantage. The gold leaf must not be applied to this size for at least 24 hours after its application, and it will remain tacky for 2–3 days. When the gilding has to be finished more rapidly, japanners' gold size is generally employed. The gold leaf may be laid on this in about ½ hour after its application, as it dries very rapidly. Sometimes the gilder is compelled to prepare his work and put on the gold leaf a few minutes afterwards; in this case, gold size alone is used. But if an interval of a few hours is no object, it is customary to add oil varnish to the gold size, regulating the quantity according to the time at disposal. Linseed oil should not be mixed with gold size to retard its drying properties, because it is apt not only to destroy the adhesiveness of the size, but to sweat through and discolour the metallic leaf. A few drops of boiled oil may be added to the size occasionally, but as a general rule varnish will be found preferable to the oils.

Writings.—(*a*) For illumination on a large scale, ordinary gilders' size can be used on stout paper. For fine work or water-matt, gold size is useful, but not easy to bring to a smooth surface. Clear gum arabic, used as thickly as is convenient for the paint-brush, makes a good ground for the gold leaf. The ordinary gilding size must be left till it is tacky, that is, all but dry. Having seen that the size is properly tacky, or having breathed on the water size or gum, lay the gold leaf on the work, pressing a piece of slightly-greased paper gently on with the fingers. In a few minutes take up the paper rather briskly from the work, and it should bring away all superfluous gold.

(*b*) Letters written on vellum or paper are gilded in three ways. In the first, a little size is mixed with the ink, and the letters are written as usual; when they are dry, a slight degree of stickiness is produced by breathing on them, upon which the gold leaf is immediately applied, and by a little pressure may be made to adhere with sufficient firmness. In the second method, some white-lead or chalk is ground up with strong size, and the letters are made with this by means of a brush; when the mixture is almost dry, the gold leaf may be laid on, and afterwards burnished. The last method is to mix up some gold powder with size, and to form the letters of this by means of a brush.

Zinc. — First coat the zinc with copper by the electrotype process, using an alkaline copper bath, and then gild on the copper, as that takes gold very readily. Organ pipes should be first coated with mastic varnish, and then oil-gilded in the usual manner.

Dissolving Gold from Gilt Articles.—(*a*) Iron and steel articles are ungilt, without any injury to themselves, by dipping them into a bath of 10 parts potassium cyanide and 100 of water, and connecting them with the positive pole of a battery. A wire or foil of platinum is fixed to the negative pole. This is inverting the position of the poles; and in this case the gold applied upon the iron or steel is dissolved in the solution of cyanide, and partly deposited upon the platinum anode, from which it is removed in a regular gold bath. When there is only a film of gold upon iron or steel, it may be removed by the cyanide alone, without the aid of electricity, but this method is slow. Silver, copper, and their alloys may also be ungilt by this process; but the cyanide dissolves, at the same time, the gold, and part of the other metals; it is therefore preferable to operate as follows:—

(*b*) For ungilding silver, it is heated to a cherry-red heat, and immediately thrown into a pickle of more or less diluted sulphuric acid. The gold scales off, and falls to the bottom in the shape of spangles. The operation is repeated until gold no longer appears upon the surface of the silver, which is then white and frosty. This process is not adapted to light and hollow articles, for which the preceding process is better.

(*c*) For copper and its alloys, in small articles, such as false jewellery thinly gilt, either by battery or by dipping, use the following bath—Sulphuric acid, 10 parts; nitric acid, 1; hydrochloric acid, 2. The large quantity of sulphuric acid allows of the solution of gold, whilst it does not sensibly attack copper or its alloys. The sulphuric acid is put alone into a stoneware jar, and the mixture of hydrochloric and nitric acids, kept in a stoppered bottle, is gradually added to it as the operation proceeds. The same sulphuric acid may last a long time, if it is kept well covered, and its dissolving action promoted by successive additions of nitric and hydrochloric acids. The articles should be often withdrawn to watch the operation, which is terminated when no gold is seen, and when the copper has acquired a uniform blackish-grey coat; or by plunging the objects into the compound acids, they will be perfectly cleansed when the gold has all dissolved.

(*d*) Saltpetre and common salt may be substituted for nitric acid and hydrochloric acid; the salts must be finely powdered, and stirred with a glass rod.

(*e*) For large objects, such as clocks or chandeliers, concentrated sulphuric acid, 66° B., is put into a glass or stoneware vessel supporting two brass rods. One of these rods is connected by a conducting wire with the last carbon of a battery of 2 or 3 Bunsen's inverted elements, and supports the objects to be ungilt, which are entirely covered by the sulphuric acid. The other rod supports a copper plate facing the object, and is connected with the last zinc of the battery. The electric fluid traverses the sulphuric acid, and carries the gold from the positive to the negative pole; as the copper plate is not prepared for retaining the gold, it falls to the bottom of the bath in a black powder, which is easily recovered. So long as the sulphuric acid is concentrated, and even under the action of the galvanic current, it does not sensibly corrode the copper; and as it rapidly absorbs the dampness of the atmosphere, the vessel in which it is contained should be kept perfectly closed, when the ungilding process is not in active operation; and the pieces for ungilding should be put in perfectly dry. If it is intended to sacrifice the gilt articles of copper or silver, let them remain in pure nitric acid, which dissolves all the metals except gold, which either floats at the surface of the liquid as a metallic foil, or falls to the bottom as a blackish powder. If the liquor is diluted with distilled water, and filtered, all the gold will remain on the filter, and the solution will contain the other metals.

(*f*) Apply a solution of borax, in water, to the gilt surface, with a fine brush, and sprinkle over it some fine powdered sulphur. Make the piece red hot, and quench it in water. The gold may be easily wiped off with a scratch-brush, and recovered by testing it with lead.

(*g*) Gold is taken from the surface of silver by spreading over it a paste, made of powdered sal ammoniac, with aquafortis, and heating it till the matter smokes, and is nearly dry, when the gold may be separated by rubbing it with a scratch-brush.

Iridium Deposits.—The problem of electroplating with iridium has been solved by employing a suitable solution of the metal and properly regulating the electric current. The solution is kept at uniform strength by using a plate of iridium as the anode. The metal takes a good polish. A buffing-wheel that will grind off nickel plating in a few moments only serves to polish iridium. Thin platinum foil, coated with iridium, retains its flexibility; and if the coating is not too thick, it will not readily scale off. Copper plates for engravings, faced with iridium, would possess marked advantages over steel engravings.

Iron and Steel Deposits.—Iron may be deposited by the wet way, but is very easily oxidised. It is obtained by decomposing by the battery a perfectly neutral iron protochloride. This bath is rapidly altered by the air, and is transformed into sesquichloride, which is unsuited for the purpose. The double chloride of iron and ammonium, obtained by the protracted boiling of a solution of sal ammoniac upon iron filings, produces a very thin deposit of iron, very difficult to oxidise, which is employed for hardening the surface of engraved plates or of ordinary electrotypes. Double sulphates of iron and ammonia, or of iron and potash, and double chlorides of the same bases, have been successfully used for electro-deposits of iron.

Lead Deposits. — (*a*) Electro-metallurgists do not write in favour of the electro-deposition of lead, viewing it from a commercial point of view. But some persons view the operation with interest, as a means of coating iron with lead to resist the attacks of acid. Following are the results of some experiments with the only promising solution of lead at command, and the course of reasoning which led up to them:—

Reviewing the scanty information obtainable on the subject, and the solutions used by other experimentalists, we were led to abandon all thought of using an acid solution, because the free acid liberated at the cathode would have a tendency to attack both the deposited metal and the metal on which it was deposited, and in this way cause a loose deposit. A similar reason led us to reject a solution of the double cyanide of lead and potassium. Knowing that caustic soda has no action on iron, but will readily dissolve an anode of lead, we decided to use a solution of soda plumbite prepared as follows: Dissolve ¼ lb. best caustic soda in ½ gal. distilled water made to boil in an iron saucepan; when the caustic alkali is all dissolved, add ½ oz. litharge, and stir well until all the litharge is dissolved. Allow the liquid to cool; carefully decant it from the saucepan into a stoneware vessel, and add 1 qt. more distilled water, when the solution will be fit for use. The iron to be coated with lead must be freed from rust and scale by filing, and then scouring with sand and water until bright. It must then be put at once into the depositing solution. Attached to the wire leading from the zinc element of the battery, a sheet of lead, slightly larger than the article to receive the deposit, must be suspended in the solution from the wire leading from the copper element of the battery, and care must be taken to have the battery elements larger in surface exposed to the liquid than that of the lead anode.

Deposition must be allowed to proceed slowly, and it will be found that an E.M.F. of 1 volt, or the current from one Daniell cell alone, will be amply sufficient to decompose the solution, and throw down a reguline adherent coat of lead on the iron.

On raising the E.M.F. to 1½ volts a slightly porous imperfectly-adherent deposit was obtained, whilst 2 volts gave a crystalline non-adherent deposit. The crystals formed with great rapidity on increasing the force of the battery, and quickly resolved themselves into large granular lumps when the force had been raised to 12 volts, whilst at the same time hydrogen was given off in abundance from the anode in a mass of frothy foam. It will thus be seen that the necessary conditions to ensure a reguline deposit of lead upon iron may be obtained from a constant battery of low E.M.F., such as the Daniell, operating on a solution of soda plumbite with an anode of sheet-lead. Should the deposit show a tendency to form in crystals, it will be well to take the articles out of the solution, rinse them in water, and burnish down the crystals with a burnisher of polished steel, after which the articles may be replaced in the solution to receive a thicker coat. A similar operation must be performed when the required coat has been deposited, and thus a smooth surface secured before the lead becomes oxidised.

(*b*) After the soda plumbite bath has cooled off, the metallic or metallised article, connected with the positive pole, is dipped into it. Then the platinum wire, communicating with the negative pole, is gradually introduced into the liquor without touching the article, which is immediately coloured in various shades; too much intensity in the current will hide all the various tinges under a uniform dark brown coat. When an article is unsatisfactory in its colouration, dip it rapidly into aquafortis, to dissolve the lead oxide, and restore the metallic surface to its primitive state. This process may be used for the decoration of stoneware and porcelain previously coated with platinum.

(*c*) Prof. Emerson Reynolds thus describes one of the best methods of applying his new process of galenising, or covering with lead various substances. Take 16 grm. solid sodic hydrate (NaOH), dissolve it in 1·75 litres water, and add to the liquid 17 grm. lead nitrate ($Pb2NO_3$) with 250 cc. water; raise the temperature of the mixture to 194° F. If sufficient lead salt has been added, the liquid will remain somewhat turbid after heating, and must then be rapidly strained or filtered through asbestos or glass-wool, into a convenient vessel. The filtered liquid is then well mixed with 100 cc. hot water containing in solution 4 grm. sulpho-urea or thiocarbamide. If the temperature of the mixture be maintained at about 168° F., deposition of galena in the form of a fine adherent film or layer quickly takes place on any subject immersed in or covered with the liquid, provided the object be in a perfectly clean condition and suitable for the purpose. When the operation is properly conducted, a layer of galena is obtained, which is so strongly adherent that it can be easily polished by means of the usual leather polisher. It is not necessary to deposit the galena from hot liquids, but the deposition is more rapid than from cold solutions.

The most convenient solution for deposition on brass is thus prepared. Take a quantity of soda lye containing $1\frac{1}{2}$ oz. real soda (NaOH); dissolve in this, with the aid of heat, 3 oz. lead tartrate, and just before diluting the solution to 1 gal. cold water, add 5 dr. sulpho-urea previously dissolved in a small quantity of hot water. The articles are to be immediately immersed in this bath, and the temperature raised to boiling. When the desired tint is obtained, the articles are to be removed, washed, and polished. The above solution can be used for glass or porcelain, hot or cold, if the proportion of alkali be reduced one-third or thereabouts.

Mercury Deposits.—These are exclusively applied on glass, for making mirrors, but the method is almost obsolete, giving place to silver, see p. 341. The substance employed to make the mercury or quicksilver adhere to the surface of the glass is tin-foil, as thin as paper, and which has a strong attraction for mercury. A drop of mercury combines with the tin-foil, and they become one substance, which adheres pretty firmly to glass. The glass is made perfectly clean on both sides, particularly on that which is to be silvered. If the slightest speck of dirt be allowed to remain on the surface, it will appear very conspicuous when the glass is silvered. The tin-foil is generally made in sheets about 6 ft. long and of various widths, varying from 10 up to 40 in., the diversity of widths being to enable the silverer to cut out small pieces suitable to various-sized glasses. For larger sizes, the foil is generally made to order, and of greater thickness than for smaller glasses. A sheet of tin-foil being unrolled, it is laid down flat, and cut to the same shape as the glass, but an inch larger each way. It is then laid down as smoothly as possible on the silvering stone, which is a very large and carefully-prepared slab of slate, porphyry, or marble, perfectly flat and smooth. The foil is worked out level and smooth on the silvering stone by means of a smooth wooden roller, which is worked over it in every direction. The silverer pours some mercury into a wooden bowl, and then, by means of an iron ladle, pours the mercury over the whole surface of the foil till every part is covered. The glass plate is then laid upon the liquid mercury; but it is not laid at once flat down on it, being made to slide on, the edge of the glass first coming in contact with the mercury. As it is slid along, it pushes before it the greater part of the mercury, because the edge of the glass almost scrapes along the foil as it passes, that all air-bubbles and impurities may be pushed off, allowing only a thin film of very pure mercury to remain between the glass and the foil. In this much care and delicacy are required. It is a matter of some difficulty to clean the glass so perfectly as not to show any marks or streaks after it is silvered. It is often necessary to remove it from the foil two or three times after it has been laid down, to wipe off specks of dirt which are visible when the glass is silvered, however difficult of detection they may previously be; this is especially the case in damp weather. This renders it necessary that the foils for large glasses, which necessarily require a longer time than small ones to perform the different processes, should be thicker than those for smaller; for such is the attraction between the mercury and the foil, that if a glass, after having been removed for further cleaning, is not speedily replaced on the mercury, the latter will combine with the foils and give it a rottenness which will prevent its adhesion to the glass; the thicker the foil, the less this is likely to occur.

When the glass is properly placed on the tin-foil, and it is ascertained that all specks and air-bubbles are removed, it is covered almost in every part by heavy iron or leaden weights; so that a large glass will have several hundred-weight pressing upon it. This pressure is to force out from between the glass and the foil as much mercury as possible, so that the thinnest film only shall remain between them. To effect this more completely, the silvering stone is made to rest on a swivel underneath, by which it can be made either perfectly horizontal, or thrown into an inclined position. While the glass is being laid on the foil, the silvering stone is horizontal, to prevent the mercury from flowing off; but when the superfluous mercury is to be drained off, the stone is made to assume an inclined position, so as to ensure one general direction for the flow of the mercury. A hollow groove runs round the sides of the stone, into which the mercury flows as it is forced out from between the glass and the foil. A pipe, descending from one corner of this trough, conveys the mercury into a bottle placed beneath to receive it. Although an immense weight of mercury must be poured on the foil for the silvering of a large glass, yet the quantity which actually remains between the glass and the foil is extremely small. The glass, with the weights upon it, is allowed to remain in the inclined position for several hours, or, if the glass is large, it is allowed to remain until the next day, in order that as much as possible of the mercury may be pressed out before the weights are removed. On the removal of the weights, one end of the glass is tilted up and supported by blocks, the other end still remaining on the stone. A piece of foil is then laid on the lowest corner, to draw off the mercury which collects in a little pool at the bottom of the glass. In this state the glass remains from a few hours to 3 or 4 days, according to its size. When as much of the mercury as possible has drained from the glass in this way, the glass is taken up, when it is found that the two metals have combined together, and in the combined state adhere to the glass, which neither the one nor the other would have done separately. The removal of the glass from the stone is effected in different ways, according to its size. If it is not too wide for the arm-span of the silverer, he takes it by the two edges, lifts it from the stone, and places it edgeways on a shelf or on the floor of the silvering room, resting its upper edge against the wall, and allowing one corner to be lower than the rest, so as to facilitate the draining towards that corner. If the glass is long and narrow, two men take it up instead of one, but in the same manner. If, however, the glass is very large, the following mode is sometimes adopted. The draining room is situated beneath the silvering room, and an opening in the floor of the latter is so arranged that a portion of the silvering table can be let down through it, on account of its facility of motion round the swivel. By a gradual turning of the silvering table, the stone and the glass upon it can be brought into a nearly perpendicular position. In this position of the glass, several men in the lower room grasp it by the edges, and place it against the wall of the room, where it is left to drain. When the plate is thus placed against the wall of the room, it is left to drain for a time, varying from one day to several days, according to its size, in order that any remaining superfluous mercury may leave it, and that the foil may become still better attached to the surface of the glass. When the draining appears to be complete, the glass is ready to be applied to its intended purpose. The above is the process for silvering plate glass. But there is an important reason why common glass, used for cheaper purposes, such as the inferior sort of dressing-glasses, cannot be silvered in this way; for any heavy pressure on such glass breaks it at once, on account of its thinness and crookedness. These common glasses, which are always small in size, are not silvered on a stone, but on a board or flat box. The foil is cut to the requisite size, and laid on the board and covered with mercury, as in the former instance. But instead of sliding the glass on to the mercury, a piece of clean paper is laid on the mercury, and the glass is laid on the paper. The silverer now, laying one hand pretty firmly on the glass, takes hold of the edge of the paper with the other, and by a quick motion, draws out the paper from between the glass and the foil, and with it the greater part of the mercury, together with air-bubbles and impurities—leaving the glass resting on a thin but brilliant film of mercury; this is a process requiring much manual dexterity. The common glass employed for these purposes is always irregularly bent at its surfaces; it is a general rule to silver the concave side, when one side is more concave than the other. The crown glass now made is better than that which was produced a few years ago, and although it is always curved, yet the curvature is pretty nearly the same in different tables from the same crate. This circumstance assists the silverer, for each silvered glass acts as a weight to another of the same size. It is usual to silver a great number of the same size at the same time; and as each one is silvered, it is placed flat down on a shelf, or in a shallow box; and on it the others are successively laid as they are silvered. The concave side of each is silvered, and as the concavity is nearly equal in all, each one helps to press out the superfluous mercury from the one beneath it. The silvering in common glasses is seldom found to be so perfect as on plate glass, from the impossibility of giving equal pressure in every part.

Nickel Deposits.—(*a*) Nickel deposited by the wet way is white, with a slightly yellow tinge, having a dull pearl-grey dead lustre; it is obtained by dissolving nickel nitrate in its own weight of ammonia, and diluting the whole with 20–30 times its volume of liquid soda bisulphite, marking about 24° B. This application is found useful when articles require to be protected against the oxidising action of damp or salt air, sulphurous gases, and weak acids. Nickel electrotypes stand the wear and tear caused by ink and press much better than the ordinary copper ones.

(*b*) Another bath is a solution of nickel nitrate, without excess of acid, precipitated by potassium cyanide, and the precipitate redissolved by more cyanide. An acid solution of nickel may be precipitated by alkalies, such as potash, soda, or ammonia; after washing the precipitate, dissolve in potassium cyanide. A moderate battery power and nickel anodes are employed.

(*c*) Without a Battery.—Into the plating vessel, which may be of porcelain or copper, place a concentrated solution of zinc chloride, dilute it with 1–2 volumes of water, and heat to boiling. If any precipitate separates, it is to be redissolved by adding a few drops of hydrochloric acid. As much powdered zinc as can be taken on the point of a knife is thrown in, which covers the vessel internally with a coating of zinc. The nickel salt, for which purpose either the chloride or sulphate may be used, is added until the liquid is distinctly green; then put in the articles to be plated, previously thoroughly cleaned, together with some zinc fragments. Continue the boiling for 15 minutes, when the coating of nickel is completed. Well wash the articles with water, and clean with chalk. If a thicker coating is desired, the operation may be repeated. Wrought and cast iron, steel, copper, brass, zinc, and lead have been successfully coated by this process. It is necessary that the objects should be entirely covered by the plating liquid, and that their surfaces should be thoroughly cleaned. Salts of cobalt, treated in the same manner, afford a cobalt plating, which is steel grey in colour, not so lustrous as the nickel, and more liable to tarnish.

(*d*) The plant necessary to commence nickel plating consists of a battery, preferably of the Smee type, with carbon negative; a well-bolted oblong wooden tank, of a size to suit the articles to be plated, coated on the inside with good asphalt, and nearly filled with the nickel solution; nickel plates for anodes, and brass rods to suspend the plates and work in the bath; suitable vessels for an alkali, an acid, and soft water for cleaning the work before placing it in the nickel bath; polishing and buffing lathes, rouge, crocus, &c. The bath may be composed either of nickel chloride and ammonia or the corresponding sulphate, dissolved in pure water. If the latter is used, the solution must be kept neutral and up to about 6°. It is prepared by dissolving $\frac{3}{4}$lb. of the salt in each gallon of water. This salt is generally considered the best for nickel plating. The chloride bath requires about 4 oz. of the salt per gallon, and works better with a slight acid reaction, the tendency in working being towards alkalinity, even with great exposure of anode. The intensity of battery current must be proportioned to the bath, and remain constant. Large baths offer less resistance to the electric current than those of smaller dimensions, and can therefore be worked with a current of somewhat less tension. For a bath of 10 gal. or less, the tension of the current should be equal to that of 2–3 Smee cells (carbon and zinc) in series. The exposed surface of the nickel anodes should in no case be less than the surface to be coated, but may with advantage be greater. The amount of battery power for a given amount of work should be in zinc surface equal to the surface to be coated, with care to preserve the normal tension of the current. If the current is too intense the coating will present a dull white or frosted appearance. The anodes must be in connection with the negative plate (carbon) of the battery. Damage is not unfrequently done to the bath and work by misconnection. The work should be scrupulously clean when entered to the bath, and should be carefully moved about after entering to free it from any adhering air-bubbles. If the finished work is to have a smooth polishing surface it must present such a surface before entering the bath. Nickel is hard and cannot well be burnished. Traces of oil and grease are removed by a hot soda solution. After dipping in clean water the surface is freed from films of oxide by an acid bath. If the work is of iron the acid may be hydrochloric diluted with 3–4 volumes of water; if of copper or brass, of nitric acid diluted with about 20 parts water. Brighten the work in the acid dip, then immerse momentarily in water; go over it with a clean stiff brush and very fine sand; again dip in the acid, then quickly in soft water, and place immediately in circuit. The hand must not come in contact with the surface of the work after removal from the alkali, as the slightest touch may spoil all. On removal of the work from the plating bath it should be immediately dipped in cold water and transferred to hot water, which will cause it, when taken out, to dry quickly and perfectly. The bath should be covered when not in use, to keep out dust and prevent as much as possible its evaporation.

By a little practice and proper attention to these simple rules the nickel bath may be worked continuously, month after month, and the metal deposited smoothly and with certainty. Magneto-electric machines, such as those of Gramm and Weston, are now gradually replacing galvanic batteries in large electro-plating establishments.

(*e*) Complaint is often heard against white nickeling not succeeding. This may be due to the current, that is too weak or too strong, or to the composition of the bath, but frequently the cause is to be sought in the nickel film being too thin, so that the metal beneath, which is generally brass, shows through. In the case of iron this is not so striking, owing to the similarity in the colour of iron and nickel. But here there is another disadvantage of thin nickeling, that the iron rusts. There is always danger of rusting, even when well plated, if the iron has been cleansed in acid. This evil may be entirely overcome by using the sand blast instead of acid pickle. Another advantage gained is that the surface is roughened and the nickel adheres to it better, while subsequent polishing is unnecessary.

Experience has shown that scythes cannot be put in pickle before nickeling, as they soon become checked or cracked in the bath. Some scythes were polished with sand blast, and then nickel plated with entire success. This would seem to solve the problem of how to best protect scythes from rust, for the innumerable experiments and attempts to protect them with varnishes have always given negative results.

One difficulty often met with in nickel plating brass and zinc should not go unmentioned. These and other metals which are flexible, yet only slightly elastic, do not quite return to their original shape after the bending force has been removed, while nickel is so elastic that it endeavours to return to its former position.

This is frequently the cause of nickel plate getting loose when deposited on these metals. A thin layer of nickel sticks better, but, as already mentioned, does not prevent the other metal from showing through, while it offers little or no protection against oxidation.

(*f*) By the process used at Mons, in Belgium, a thick plating of nickel may be deposited upon any metal by a feeble electric current in a very short space of time. The composition of the bath is as follows: Nickel sulphate, 1 kilo.; neutral ammonia tartrate, ·725 kilo.; tannic acid, ·005 kilo.; water, 20 litres. The neutral ammonia tartrate is obtained by saturating a solution of tartaric acid by ammonia. In the same manner the nickel sulphate must be exactly neutralised. Three or four litres of water are at first added, and the solution is made to boil about ¼ hour. The rest of the water is then added, and the liquid is filtered or decanted. This bath may be renewed indefinitely by adding the same materials and in the same proportions. The deposit obtained is brilliantly white, soft, and homogeneous. Even when obtained of great thickness there are no irregularities on the surface, and it has no tendency to scale. Some very thick deposits of nickel upon both rough and polished cast-iron goods have been obtained by this process at a cost scarcely exceeding that of copper.

(*g*) For the baths, Gaiffe gives the following formula:

Nickel and ammonium, double sulphate	1 kilo.
Distilled water	10 litres.

Roseleur prefers to take:

Double sulphate	400 grm.
Ammonium carbonate ..	300 grm.
Distilled water	10 litres.

Each of the two salts is dissolved separately in a part of the water. The solution of ammonium carbonate is gradually poured into that of nickel, taking care not to pass the point of neutrality. The quantity of 300 grm. ammonium carbonate indicated above is not obligatory, but may be varied according to the quality of the salt of nickel.

(*h*) Adams proposes the two following mixtures:

Chloride.—Take 135 grm. pure nickel, and dissolve in hydrochloric acid, avoiding excess, and heating gently. When all is dissolved, add 2·25 litres cold water, and add gradually ammonia until the liquid is neutral to litmus paper. Dissolve separately 70 grm. sal ammoniac in water, and mix with the former solution, and make up to 10 litres with cold water.

Sulphate.—Dissolve 135 grm. pure nickel in sulphuric acid diluted with twice its weight of water, and heat until the metal is dissolved. Add water and neutralise with ammonia. Dissolve separately 70 grm. ammonium carbonate, and neutralise the solution carefully with sulphuric acid. Add this liquid to the nickel sulphate, and make up to 10 litres with cold water. In both cases filter the liquids or dilute after standing. Adams ascribes a good deposit of nickel to the absence of potassa or soda, while in reality excellent deposits may be obtained in ammoniacal baths containing salts of potassium or sodium.

(*i*) A short time ago nickel plating was nearly as expensive as silver plating. This is explained by the fact that only a few people, at least in this country, were expert in the mechanical portions of the process, and only a very few chemists gave attention to the matter. To this must be added that our text-books were fearfully deficient in information bearing on this subject.

The salt used, and also the anodes, were originally introduced into this country from America, and latterly from Germany. I am not aware of any English manufacturer who makes a specialty in the way of anodes. This is a matter on which we can hardly congratulate ourselves, as a well known London firm some time ago supplied me with my first experimental anodes, which were in every way very superior to the German or American productions. Although the price paid per pound was greater, the plates themselves were cheaper on account of their lesser thickness.

The texture of the inner portions of these foreign anodes would lead one to infer that the metallurgy of nickel was very primitive. A good homogeneous plate can be produced, still the spongy, rotten plates of foreign manufacture were allowed the free run of our markets. The German plates are, in my opinion, more compact than the American. A serious fault with plates of earlier manufacture was their crumpled condition after a little use. This involved a difficulty in cleaning them when necessary. The English plates were not open to this objection; in fact, when the outer surfaces were planed away, they remained perfectly smooth and compact.

Large plates have been known to disintegrate and fall to pieces after being used for some time. A large anode surface, compared with that of the article to be plated, is of paramount importance. The tank should be sufficiently wide to take the largest article for plating, and to admit of the anodes being moved nearer to or farther from the article. In this way the necessary electrical resistance can very conveniently be inserted between the anode and cathode surfaces. The elimination of hydrogen from the cathode must be avoided, or at any rate must not accumulate. Moving the article being plated, while in the bath, taking care not to break the electrical contacts, is a good security against a streaky or foggy appearance in the deposit.

At one time a mechanical arrangement was made, by which the cathodes were kept in motion. The addition of a little borax to the bath is a great advantage in mitigating the appearance of gas. Its behaviour is electrical rather than chemical. If the anode surface is too great, a few plates should be transferred to the cathode bars.

When an article has been nickel plated, it generally presents a dull appearance, resembling frosted silver. To get over this I tried, some time ago, the use of carbon bisulphide in the same way as used for obtaining a bright silver deposit. Curiously the deposit was very dark, almost black, which could not be buffed or polished bright. But by using a very small quantity of the bisulphide mixture, the plated surfaces were so bright that the use of polishing mops or buffs could be almost dispensed with. When we consider the amount of labour required in polishing a nickel plated article, and the impossibility of finishing off bright an undercut surface, this becomes an important addendum to the nickel plater's list of odds and ends.

This mixture is made precisely in the same way as for bright silvering, but a great deal less is to be added to the bath, about 1 pint per 100 gal. It should be well stirred in, after the day's work is done, when the bath will be in proper condition for working next day. The mixture is made by shaking together, in a glass bottle, 1 oz. bisulphide, and 1 gal. of the plating liquid; allow to stand until excess of bisulphide has settled, and decant the clear liquid for use as required. It is better to add this by degrees than to run the risk of overdoing. If too much is added, the bath is not of necessity spoiled, but it takes a great deal of working to bring it in order again.

About 8 oz. of the double sulphate to each gallon of distilled or rain water is a good proportion to use when making up a bath. There is a slight excess with this. It is a mistake to add the salt afterwards, when the bath is in good condition. The chloride and cyanide are said to give good results. I can only say that the use of either of these salts has not led to promising results in my hands.

In preparing the double sulphate, English grain nickel is decidedly the best form of metal to use. In practice, old anodes are generally used.

The metal is dissolved in a mixture of nitric and dilute sulphuric acid, with the application of a gentle heat. When sufficient metal has been dissolved, and the unused nitric acid expelled, the salt may be precipitated by a strong solution of ammonia sulphate, or, if much free acid is present, ammonia carbonate is better.

Tin, lead, and a portion of the iron, if present, are removed by this method. The silica, carbon, and portions of copper are left behind with the undissolved fragments of metals.

The precipitated salt, after slight washing, is dissolved in water, and strong solution of ammonia is added. A clean iron plate is immersed in the solution to remove any trace of copper. This plate must be cleaned occasionally so as to remove any reduced copper, which will impede its action. As soon as the liquid is free from copper, it is left alkaline, and well stirred so as to facilitate peroxidation and removal of iron, which forms a film on the bath. When this ceases, the liquid is rendered neutral by addition of sulphuric acid, and filtered or decanted. The solution, when properly diluted, has sp. gr. about 1·06 at 60° F. It is best to work the bath with a weak current for a short time until the liquid yields a fine white deposit. Too strong a current must be avoided.

If the copper has not been removed, it will deposit on the anodes when the bath is at rest. It should then be removed by scouring.

Copper produces a reddish tinge, which is by no means unpleasant compared with the dazzling whiteness of the nickel deposit. If this is desired, it is far better to use a separate bath, with anodes of suitable composition.

The want of adhesion between the deposited coating and the article need not be feared if cleanliness be attended to and the article, while in the bath, be not touched by the hands.

The bath should be neutral, or nearly so, slightly acid rather than alkaline. It is obvious that, as such a liquid has no detergent action on a soiled surface, scrupulous care must be taken in scouring and rinsing. Boiling alkaline solutions and a free use of powdered pumice and the scrubbing brush must on no account be neglected.

A few words on the construction of the tanks. A stout wood box, which need not be watertight, is lined with sheet lead, the joints being blown, *not soldered*. An inner casing of wood which projects a few inches above the lead lining is necessary in order to avoid any chance of "short circuiting" or damage to the lead from the accidental falling of anodes or any article which might cut the lead. It is by no means a necessity that the lining should be such as to prevent the liquid getting to the lead.—(T. Bruce Warren.)

(*k*) Successful electroplating in general depends on three conditions: on the quantity and properties of the metallic solution (the bath); on the strength of the current, and its relation to the surface of the pole, which determines the thickness of metal deposited in a unit of time (rapidity of precipitation); and on the nature of the surface of the pole on which the metal is to be deposited. If the pole is of metal and is to be inseparably united with the deposit, as is the case with silver plating, the surface must be perfectly clean and free from oxide or grease. If the surface is dirty, the precipitate peels off. It will not adhere at all to a non-metallic substance, but merely encloses it.

It is a fact worthy of attention that under otherwise similar conditions many metals do not take certain deposits well. In some cases the deposit is streaked, powdered, or of bad colour, and in others it peels off afterwards when polished. Iron in its different forms (steel, wrought iron, or cast iron), zinc, lead, and tin cannot be readily silvered or gilded in the cyanide bath, although it works first-rate on copper and its alloys, and is generally used for that purpose. But of the copper alloys German silver causes more difficulty than brass. Copper, brass, and iron are easily plated in the nickel bath ; zinc, on the contrary, is not. In some of these cases the metal to be plated acts directly on the solution itself, as, for example, zinc acts on silver and nickel solutions, and this circumstance may affect the properties of the whole deposit; this does not happen with iron.

If a metal cannot be nicely plated in a bath, it is customary to cover it first with some other metal of better quality in this respect. Thus iron, zinc, and tin are easy to silver and gold plate after they have been copper plated, and zinc can also be nickel plated under these conditions.

To unite the deposit as firmly as possible with the object, it has been found in many cases advantageous to slightly amalgamate the surface of the metal to be plated, especially in giving a thick coating of silver to instruments. The method is extremely simple, for it is only necessary to dip the articles for a short time into a mercurial solution and then rinse them with water.

The quantity of mercury used is insignificant ; in fact a heavy amalgamation must be avoided, as it would make the metal brittle. A mercurial solution serviceable for this purpose is made with the commercial mercuric nitrate or chloride (corrosive sublimate). The solution must be very dilute, about 1, 5, or at most 10 parts of the dry salt in 1000 of water ; to this solution some sulphuric or chlorhydric acid is to be added until the liquid is perfectly clear. The stronger solution gives up more mercury in a given time than a weaker one, and this must be taken into account in amalgamating. With practice it is easy to tell from the change of colour when enough mercury has been deposited. Iron does not alloy, or only very badly, with mercury, and hence it cannot be subjected to the process just described.

Within the last decade nickel plating has reached an extraordinary development. At first it was limited to iron, then it was gradually extended to brass and German silver, and now is increasing in favour for coating zinc. As this metal takes the nickel from ordinary baths very badly, it has been proposed to copper plate it in the cyanide bath. But this is a nuisance. The use of the poisonous cyanide bath should be avoided as far as possible, and limited to cases where it cannot be dispensed with ; in nickel plating, cyanides are not absolutely necessary, even if an intermediate layer of copper is desirable in thick nickel plating. The copper cyanide (and likewise brass) bath has a disagreeable property of only working when certain conditions are exactly observed ; it also decomposes easily. As the nickel wears off by use the red shines through, which is worse than if the white zinc itself were laid bare. Experience also showed that coppered zinc, when it came into the nickel bath, at once turned black and could not be plated.

There is not yet any literature on amalgamating zinc for the purpose of nickeling it. On many sides objections are heard against the deficiencies of the customary process of nickel plating, and it seemed worth while to make some experiments in this direction. The experiments were satisfactory. I amalgamated a sheet of zinc and then had it nickel plated by Schwerd in Carlsruhe. The nickel adhered well, united perfectly, and took a fine polish. I think it is not improbable that the nickeled sheet-zinc of commerce is prepared in a similar manner. This supposition receives support from one of the properties of this zinc to which my attention was called by Beuttenmüller, who has used a good deal of it in his factory.

It is rather brittle in comparison with pure sheet-zinc. I cannot explain this brittleness in any other way than due to amalgamation. The alloys of mercury with solid metals, called amalgams, exhibit this property, that the mercury dissolves off small quantities of the metals to form a thicker liquid; with a larger excess of the solid metals the alloys are solid, but fragile and brittle. This character remains, but grows gradually less. When a sheet of metal is amalgamated, it depends on the quantity of mercury combined with it and the depth to which it penetrates, whether it will cause a perceptible change in the strength of the metal.

Copper must remain in contact with mercury for a long time until it has penetrated a considerable depth; with zinc this takes place very rapidly. A sheet of zinc, 1 mm. thick, thoroughly cleansed in acid, only needs to have metallic mercury poured over it so that it forms a bright mirror to make it so brittle that it will not stand bending. Zinc carries this peculiarity into its alloys with copper, so that brass and German silver are much more sensitive to mercury than copper. If zinc is immersed in a mercurial solution, it will depend upon the time it stays in whether the mercury will be merely deposited upon the surface or will penetrate more deeply into the zinc. A concentrated mercurial solution will make a sheet of zinc 1 mm. thick brittle in a few minutes.

The quantity of mercury necessary for nickel plating will have an imperceptible influence on its strength if the zinc is thick; but if it is thin it may show a perceptible difference, which makes it difficult to work the zinc. Special care must be taken to prevent too much mercury being deposited on the zinc by leaving it in the solution too long. The exact quantity can only be determined by experiments that are simple and easily carried out.

When one metal is deposited on another by the galvanic current, we cannot speak of them as alloys if they are inseparable, for they are only held together by adhesion. Hence there can be no change in the characters of the two metals; neither a harder nor a more brittle product results from electroplating. If the latter is observed even in a slight degree, it is easy to conclude that there is mercury in it.

Pure zinc has a different action on nickel solutions from amalgamated zinc. The former soon turns yellow and brown, and the deposit can be rubbed off with a piece of paper. If a feeble current is employed, this chemical action preponderates, and hence we obtain a poor deposit. If the current is very strong, the zinc will be more rapidly coated with nickel by electrical action than it would by the chemical action of zinc on the solution, and a good deposit can be obtained. It is only by observing these precautions that it is possible to nickel plate zinc directly, and yet this is frequently inconvenient. If amalgamated zinc is dipped into a nickel solution, after a long time feeble action will begin. The mercury, although there is so little of it, protects the zinc against the action of the liquid, like zinc in its alloys with copper, brass, &c., is protected against the attacks of different liquids, copper sulphate, sulphuric acid, &c. Yet in all these cases the protection is incomplete; after a while a slight action is observed. In nickel plating zinc, slight amalgamation will suffice to secure a good deposit with a feeble current.

It has been observed that some kinds of German silver take nickel badly; previous amalgamation may, perhaps, be an advantage here, too.—(Prof. Meidinger.)

(*l*) A simple process of nickel plating by boiling has been described by Dr. Kaiser. A bath of pure granulated tin, tartar and water is prepared, and after being heated to the boiling-point, has added to it a small quantity of pure red-hot nickel oxide. A portion of the nickel will soon dissolve and give a green colour to the liquid over the grains of tin. Articles of copper or brass plunged into this bath acquire in a few minutes a bright metallic coating of almost pure nickel. If a little cobalt carbonate or tartrate is added to the bath, a bluish shade, either light or dark, may be given to the coating, which becomes very brilliant when it is properly polished with chalk or dry sawdust.

(*m*) Nickel plates and sheet nickel are now generally made by the manufacturers of nickelware. These may be used in the production of a solution which is particularly well adapted for nickel plating. To this end the nickel is placed on a perforated board in a saturated solution of ammonium chloride (sal ammoniac), and the metal is brought in connection with the positive pole of a strong battery. By the influence of the electric current the metal gradually becomes dissolved, and a double salt is formed (nickel ammonium chloride), which settles on the bottom of the vessel, while, at the same time, the metal is kept continually in contact with the ammonium chloride.

If the nickel has previously been weighed, the amount of the metal which has become dissolved can at any time be determined by weighing the as yet uncombined nickel. In order to nickelise with this solution, a plate of pure nickel is suspended in the fluid, and it is connected with the positive pole of the battery, while the metallic body which is to be coated, and which must, of course, be well cleaned, is connected, after it has been immersed, with the negative pole. The nickel is precipitated from the solution as a bright coat, whose thickness depends upon the length of time during which the current is acting upon it, and also upon the strength of the latter.

In order to operate directly with the nickel sulphate, it is necessary to have a salt entirely acid free, which may readily be prepared by adding a small quantity of sodium hydrate (caustic soda) to the solution of the commercial salt, after having first removed the copper in the manner which will presently be described. When the acid is neutralised, an apple-green precipitate of nickel hydrate is formed, which is boiled for some time and then filtered. The solution is now perfectly neutral.

To remove the copper from the nickel salt, the latter is first dissolved in water and acidulated by a few drops of sulphuric acid (commercial nickel sulphate is generally acid), then a current of hydrogen sulphide gas, which is prepared by pouring sulphuric acid over iron sulphide in a flask, is passed through the solution.

The copper and other metals which are likely to be present are thrown down in the form of a black precipitate. When the odour of the gas is distinctly recognised, its passage is stopped, and the solution is heated to expel the last traces of the hydrogen sulphide. It is then heated to boiling in a porcelain vessel with the addition of some metallic nickel. By this means the free acid is neutralised, and on evaporating to crystallisation there remains a salt sufficiently pure for nickel plating.

The articles which are to be plated are suspended in the solution which we have just described, and they are connected with the positive pole. A nickel plate, which also dips into the liquid, is connected with the negative pole; and from time to time the liberated acid is neutralised by the addition of a slight quantity of ammonium hydrate. It is better still, for practical results, to spread a layer of nickel oxide over the bottom of the vessel in which the nickelising is being carried on. This will dissolve in the free acid, and the solution will therefore remain neutral and of uniform strength.

The nickel oxide is prepared by completely saturating a solution of nickel sulphate with sodium hydrate (caustic soda), washing the precipitate, and then drying it. The nickel oxide thus formed is a heavy powder of an apple-green colour, and may be either spread over the bottom of the vessel, or it can be placed in a linen bag and suspended in the liquid. If a solution of nickel sulphate, acidified with sulphuric acid, is poured into a saturated solution of ammonium sulphate, crystals will separate out, consisting of the double salt of nickel ammonium sulphate. The crystals are washed with cold water, dissolved in hot water, and then the solution is completely neutralised with ammonium hydrate. It is then allowed to stand for several days at a temperature of 68°–77° F., until no more crystals separate out. It is also of importance that the liquid be maintained at this temperature during the nickelising, for otherwise the nickel will not adhere firmly to the metal.

During the operation of plating, a sheet of nickel, connected with the positive pole of the battery, is suspended in the solution. According as the nickel becomes separated from the solution the sheet dissolves, and thus the solution maintains its original strength. Plates of absolutely pure nickel are at present quite expensive, in consequence of the very high temperature which is required for their fusing and casting. By the addition of $\frac{1}{5000}$th part of phosphorus its point of fusion may be considerably lowered. As the phosphorus is not objectionable in nickelising, the plates are generally made of metal containing phosphorus, and they are used to the best advantage in rather thin sheets, for, the larger the surface of the nickel plate, the less will be the strength of the current required; and when the pieces to be plated are not large, as will occur in the majority of cases, two or three Bunsen elements will be sufficient.

In addition to the above methods for nickel plating, others have been proposed which also give good results, but which require more expensive preparations than those previously mentioned; thus, for instance, the double salt of nickel potassium cyanide and solutions of nickel nitrate have been proposed. On account of the vapours which escape from the cyanide solutions, although only in small quantities, they are particularly objectionable, and therefore the employment of cyanide preparations, on account of their poisonous properties, should be avoided whenever it is possible to do so. The nickel nitrate gives a beautiful and durable coat of nickel. The solution is most effective when it is composed of 4 parts crystallised nickel nitrate dissolved in 150 parts water, to which 4 parts ammonium hydrate are added, and then 50 parts of acid sodium sulphite are dissolved in the above solution.

The acid sodium sulphite is prepared by heating copper with sulphuric acid in a retort; the gas produced is passed through a small quantity of water, which will retain the copper which has been mechanically carried over, and then the gas (sulphurous acid) is dissolved in water until the liquid smells distinctly of burning sulphur. The solution which has thus been obtained is divided into two portions: one part is saturated with sodium carbonate as long as effervescence takes place, the other half of the acid is then added, and in this manner sodium bisulphite is produced. This must be employed as it is, because it is impossible to crystallise the salt by evaporation, for in so doing one half of the acid would escape, and sodium mono-sulphite remain behind.

For nickel plating of the finest kind, such as is produced in American factories, a solution is prepared from the nickel nitrate and acid sodium sulphite. It sometimes happens that the nickel will strip or peel off from the metals on which it has been deposited. It is said that this objection can be overcome by placing the dried plated objects in a bath of oil and heating them up to 482°–518° F.

According to Weston, a plating of great beauty and durability is obtained by mixing a solution composed of 5 parts nickel chloride and 2 parts boracic acid with one made up of 2 parts nickel sulphate and 1 part boracic acid, and then adding, while continually stirring, sodium hydrate (caustic soda) until the precipitate is redissolved.

For the nickelising of iron or steel, it is best to first coat the objects to be plated with a thin film of copper, which is readily accomplished by dipping the material into a dilute solution of copper sulphate.—(Hartman.)

Palladium Deposits. — Palladium has of recent years been much used to plate watch movements with. According to Pilet, 4 mgrm. palladium are sufficient to coat the works of an ordinary sized watch. Pilet recommends the following bath:—Water, 2 litres; palladium chloride, 10 grm.; ammonia phosphate, 100 grm.; soda phosphate, 500 grm.; benzoic acid, 5 grm. This bath is suitable for all metals except zinc.

Platinum Deposits.—(*a*) Copper and its alloys only will receive a satisfactory platinum deposit; iron, zinc, lead, or tin, coated with this metal, even after a previous coppering, give but defective results. The platinum deposits are obtained by dipping thoroughly cleansed copper articles in the following solution, kept boiling:—Distilled water, 100 parts by weight; caustic soda, 12; platinum for neutral chloride, 1. The deposit is bright, durable, and of a dark colour, resembling oxidised silver.

(*b*) The platinum baths for electro-deposits will succeed when platinum chloride is dissolved in a solution of a salt with alkaline, neutral, or acid reaction, but sulphites and cyanides, even those having soda for base, should be excepted. Distilled water, 100 parts by weight; soda carbonate, 40; platinum for neutral chloride, 1. Temperature of the bath, 160°–180° F. Distilled water, 100 parts by weight; soda phosphate or borate, 60; platinum for neutral chloride, 1. Distilled water, 100 parts by weight; soda pyrophosphate, or chloride or iodide, 30; platinum for dry chloride, 1. These baths only give exceedingly thin deposits; if the coating were allowed to increase most of it would be without adherence, and often in the form of scales. The deposit is black or steel grey.

(*c*) Fill a glass flask with $\frac{1}{3}$ oz. finely-laminated spongy or black platinum, and a mixture of $5\frac{1}{2}$ oz. hydrochloric acid and $3\frac{1}{2}$ oz. nitric acid at 40° B. Place the flask upon a piece of sheet iron perforated in the centre, so that the bottom of the flask alone receives the heat. After an abundant production of orange-yellow fumes, the platinum will disappear and leave a red liquid, which should be heated until it becomes viscous enough to stick against the sides of the flask. This latter part of the operation may be effected in a porcelain dish, the shallow form of which aids in the evaporation of the acids in excess. After cooling, the residuum is dissolved in $17\frac{1}{2}$ oz. distilled water, and filtered if necessary. Dissolve $3\frac{1}{2}$ oz. ammonia phosphate in $17\frac{1}{2}$ oz. distilled water, and mix the two solutions. This produces a precipitate of ammonia and platinum phosphate in a liquid of orange colour, which should not be separated; pour into it, stirring all the while, another solution of $17\frac{1}{2}$ oz. soda phosphate in $1\frac{3}{4}$ pint distilled water. Boil the mixture, and replace the evaporated water, until no more ammonia is disengaged, which is ascertained by the smell; and until the liquor, which was previously alkaline, begins to redden blue litmus paper. When the yellow liquor becomes colourless, it indicates the formation of a double platinum salt. The bath is then ready to deposit platinum upon articles of copper or its alloys, by the aid of heat and of an intense electric current. Copper coated with platinum resists nitric and sulphuric acids to a considerable extent. If iron, zinc, lead, or tin come in contact with the bath they will decompose it, and the metal deposited will be black. The dead lustre of platinum is pearl-grey; it is very hard, and cannot be brightened by scratch-brushes of brass, which render its surface yellow; powdered pumice or iron wires should be employed. Platinum deposits may be burnished by an energetic friction, and the lustre obtained is very durable. Platinum may be removed from copper by a very long immersion in the liquors given for ungilding, but the success is doubtful.

(*d*) Iron, tin, tin-plate, and brass may be easily platinised as follows:—Pour on 1 part platinum chloride 1 part water; acidulate with a little hydrochloric acid, and add 20 parts alcohol. Evaporate to 15 parts, and add 60–90 parts ether. Moisten a rag with this solution, and rub vigorously on the clean-scoured or polished metal. Heat to 140° F., and polish by rubbing with a woollen rag.

(*e*) A solution of 1 part platinum

chloride in 15 of alcohol and 50 of ether is rubbed over the surfaces to be platinised, the vessels being put away in a dry warm place. The surface, on being rubbed with a cotton, or, still better, a woollen rag, yields a high polish, having the appearance and lustre of steel.—(Dr. Hager.)

(*f*) The following method for the electro-deposition of the heavy metals, such as platinum, iridium, palladium, &c., has recently been proposed by Prof. Silvanus Thompson. The impure metal is first obtained as a chloride by the ordinary chemical processes. The excess of acid is evaporated off in a water bath, and the salt is finally redissolved in distilled water and 10–50 times its weight of a solution of sodium phosphate, either pure or mixed with borax. The solution is then raised to the boiling point, and sal ammoniac, common salt, or sodium bromide is added. The solution is then reheated, and finally neutralised with either soda carbonate or, if alkaline, with bicarbonate. In depositing the metal from a bath of the above solution, it should be heated to 140°–194° F., and the metal deposited in the ordinary way. In the case of platinum, a brilliant deposit can be obtained from a bath of the following composition:—

	Parts.
Platinum chloride ..	2
Sodium borate ..	16
„ carbonate ..	16
Sal ammoniac	2
Water	150

(*g*) The permanence and unalterability of the metal platinum—properties which make it of such inestimable value to the chemist—have likewise suggested its application as a protective covering upon the surfaces of other metals; and even in the early days of the art of electro-deposition efforts to obtain a satisfactory coating of this metal were made. The failure with which these early experiments were attended served rather to stimulate than to deter subsequent investigators, and the problem has received the attention of a number of the most noted experts in the art. The results that have been accomplished cannot be said to have been entirely satisfactory—a statement which will be fully sustained by the fact that electroplating with platinum, on the commercial scale, is practised only to a very limited extent. When the wide field of application for platinum plating is considered, the conclusion is irresistible that the processes thus far proposed for the purpose do not fully meet the requirements of practical service.

Thus far, of all the methods that have been proposed for electro-plating with platinum, [three only appear to have sufficient merit to deserve special notice; these are:—

1. Roseleur-Lanaux method, based on the electrolysis of a solution of the double phosphate of sodium and platinum.

2. The process of the Bright Platinum Plating Company (of London), a modification of that of Roseleur, involving the introduction into the bath of certain substances, such as sodium chloride and borax, to ensure a bright deposit of the metal; and

3. Boettger's method, founded on the electrolysis of a solution of the double chloride of ammonium and platinum in sodium citrate.

Each of these baths will yield satisfactory results for a time; but the peculiar difficulties met with in the practice of platinum-plating render it impossible to maintain the chemical integrity of these electrolytes, and, in consequence thereof, they soon become inefficient or inoperative by reason of contamination with the secondary products formed therein.

The first difficulty encountered is that of obtaining a bright, reguline, and adherent deposit of the metal, in which form only it will answer the demands of practice. There is no difficulty in effecting the separation of the metal from solutions of almost any of its compounds. Zinc, iron, and tin reduce it promptly by simple immersion, and this very facility of reduction is one of the reasons why, even by the method of electrolysis, the desired object is frequently accomplished only in an imperfect manner; for the electro-plater is obliged to meet and overcome its obstinate disposition to separate from many of its compounds in the condition of platinum black, lacking coherence and adherence, and therefore entirely unsuited for his purpose.

Another and no less serious difficulty arises from the insolubility of plates or sheets of this metal as anodes, when solutions containing platinum salts are submitted to electrolysis. In electroplating with copper, silver, gold, and nickel but little difficulty is encountered in practice on this account, since anodes of these metals are freely soluble in many solutions capable of depositing them when they are submitted to electrolysis, and the rate at which these anodes are respectively dissolved approximates so nearly to that at which the metals are deposited upon the objects at the cathode, that the metallic strength of the electrolyte is maintained substantially uniform, and electro-plating solutions of these metals may be operated for a long time without requiring additions of metallic salts. The electrodeposition of the metals whose anodes are thus tractable is carried on industrially with success.

It results from this want of solubility of the anode that the metallic strength of the electrolyte employed is continuously being weakened, while the deposition of the metal is going on and the conductivity of the bath is being continually modified thereby. The character of the deposited metal also is injuriously influenced by these constant alterations of condition in the bath; and, as the rate of deposition becomes slower and slower by reason of the gradual impoverishment of the metallic strength of the solution, it will be necessary to restore it by fresh additions of metallic salt. The practice in all the processes of electro-plating with platinum employed up to the present time, save that of Boettger, is to use for this purpose platinum tetra-chloride. With this single exception, all the solutions for the electro-depositions of platinum thus far made known are prepared by treating the chloride with compounds of the alkalies, soda, potassa, or ammonia. Of these the phosphates and oxalates of soda or potassa are in greatest favour, and a number of formulæ for preparing platinum-plating baths with their aid have been described. The resulting substance is commonly a double salt, such, for example, as the double phosphate of sodium and platinum; the double oxalate of potassium and platinum, &c., contaminated, however, in each case by the chloride of the alkali employed, which is formed from the decomposition of the platinic chloride. As often as it is found necessary to strengthen the bath, fresh additions are made of platinic chloride, which by chemical interaction with the constituents of the bath, aided by the process of electrolysis, yields more alkaline chloride; and it follows that the bath, by reason of becoming surcharged with this foreign substance, and with other secondary products of electrolytic decomposition, ceases to yield bright, reguline platinum upon the articles to be plated therewith and must be discarded. It then becomes necessary to regain the platinum contained in the discarded bath, by one or other of several processes of reduction known to chemists. The platinum thus regained may be converted into chloride and utilised in the preparation of a fresh bath with which the same series of operations will be repeated. Boettger purposes to maintain his bath by fresh additions of his original solutions, but it must be apparent that the continued electrolysis of such a solution as he employs must be attended with the constant accumulation therein of alkaline chlorides from the same causes as those specified above. This rapid deterioration of the baths, therefore, involves their frequent renewal at the expense of time and labour, so that, in spite of the fact that there is a wide field for its application, it is principally for this reason that the art of electro plating with platinum on the commercial scale has thus far been practised only to a very limited extent.

Knowing the influence of extent of surface in promoting the solubility of substances, it appeared probable that if the platinum were exhibited at the anode in the form of platinum black or sponge, exposing thus an enormously greater number of points of attack to the electro-negative element or acid radical there set free, the result might be the solution of the platinum, and the problem of maintaining the metallic strength of the electrolyte would thus be solved. The correctness of this conjecture was verified by experiment. For this purpose a plate of porous battery carbon previously treated with boiling hydrochloric and nitric acids was saturated repeatedly with a solution of platinic chloride and dried. It was then introduced into a graphite crucible, finely divided carbon was packed about it, and the crucible aud contents heated for about ½ hour to bright redness. The carbon plate then contained within its pores platinum in a state of eminently fine division. Treatment with water and with hydrochloric acid at boiling temperature failed to leach out any platinum salt, showing that the previous treatment had sufficed to reduce all the platinum salt to the metallic state. The carbon plate was then suspended as the anode in moderately dilute hydrochloric acid, a platinum plate serving as the cathode. The acid bath was gently heated, and a current of moderate strength was allowed to flow through it. There was a liberal evolution of hydrogen from the cathode, but little perceptible evolution from the anode. The acid solution gradually became coloured from the formation of platinic chloride, and after some time the bright surface of the cathode began to blacken and ultimately became covered with a thick coating of platinum black. It was thus demonstrated that an anode of platinum in a fine state of division is readily soluble in an electrolyte which yields chlorine at the anode when the same is electrolysed. This observation proved to have no practical value, since the solution of the anode demanded the presence of a large proportion of free acid in the plating bath, and the use of currents of such strength as to produce invariably the deposition, on the surfaces to be plated, of black and non-adherent metal. Furthermore, it was found, as was to have been anticipated, that the physical condition of the anode exerted no influence whatever in the electrolysis of baths formed of the oxy-salts of platinum, from which the best results in electro-plating are obtained—since, in electrolysing such compounds, the acid radical separated upon the surface of the platinum black failed to exert any perceptible solvent action.

It was therefore necessary to devise some other plan for overcoming the difficulties herein described, and, after making a number of fruitless experiments, I was so fortunate as to find a plan which appears to offer a solution of the troublesome problem of electroplating with the group of metals whose anodes are insoluble, in a more satisfactory manner than any other that has hitherto been suggested.

The plan here referred to consists in employing platinum hydroxide for the purpose of maintaining the metallic strength of the plating bath. For this purpose the hydroxide, which is readily soluble in alkalies and in many of the acids, may be introduced into the plating bath from time to time and dissolved therein by stirring, or it may be permitted to remain in the bath in excess, the undissolved portion remaining at the bottom of the containing vessel, or it may be suspended in a canvas bag adjacent to or surrounding the anode of carbon, according as the nature of the electrolyte may indicate one or the other method to be preferable. As the solutions which yield the best results in plating are those of the oxygen salts, it is advantageous also to prepare these directly from the hydroxide. This method is capable of yielding a number of electrolytic baths of platinum that will maintain their metallic strength approximately unimpaired during electrolysis, and without the objectionable features of introducing into them substances that will cause them to deteriorate by the accumulation therein of injurious secondary products of decomposition, as is the case where such baths are maintained by additions of platinic chloride or alkaline chloroplatinates, as has hitherto been the invariable practice. Referring now specifically to the properties that render the platinic hydrate useful for the purposes above indicated, the following points appear to be deserving of mention.

It is readily soluble in aqueous solutions of the alkaline hydrates, and in a number of acids, mineral and vegetable. In the treatment of the platinic hydrate with aqueous solutions of the alkaline hydrates, the former plays the part of a weak acid forming compounds known as platinates, which are very soluble, and from which the platinum is not precipitated on the addition of an excess of alkali. A weak aqueous solution of sodic or potassic hydrate (but especially the last named) will dissolve a large quantity of platinic hydrate, at the ordinary temperature, though solution takes place more freely when heat is applied. These solutions have the advantageous features of being freely conductive of electricity, and of yielding bright, reguline, and adherent electro-deposits of platinum on metallic surfaces previously prepared to accept the same. Furthermore, with a current of moderate strength, the platinic hydrate only is affected, as is shown by the pronounced evolution of oxygen at the anode and by the total absence of gas at the cathode. Also, it is manifest from the free solubility of platinic hydrate in alkaline hydrate, even in the cold, that if free platinic hydrate be present in a bath of alkaline platinate, the alkali set free in the process of electrolysis will combine with this platinic hydrate to form fresh platinate. For this purpose, it will be necessary either to have present in the bath at all times a small excess of platinic hydrate which may remain upon the bottom of the containing vessel, without interference with the plating, and which may be replenished from time to time; or, to introduce at the end of the day's work a quantity of the platinic hydrate sufficient to restore the metallic strength of the bath to the normal, assisting the solution of the metallic hydrate by stirring, and if necessary, by the application of gentle heat. As platinate solutions act best when they contain a considerable excess of free alkaline hydrate, being more conductive of the current and yielding the platinum more freely and in the best condition, the addition of the proper quantity of platinic hydrate at the close of the day's work in the case of a bath of considerable volume, or the addition of small quantities at intervals, in the case of a small bath, will be found to answer the desired purpose of maintaining the metallic strength of the bath approximately normal for an indefinite period. In a bath where considerable free alkali is present, the platinic hydrate added as just indicated dissolves very freely, even in the cold. The important fact is to be noticed, that the alkaline platinate solutions may be maintained and operated for a long time in the manner described, since no deleterious secondary products are formed by electrolysis to vitiate and render them inoperative, as will speedily be the case where the platinic chloride is used for this purpose. The mineral acids (hydrochloric, nitric, sulphuric, and phosphoric acids) dissolve the hydroxide freely, as likewise do certain of the vegetable acids, notably oxalic acid, and form with corresponding salts of the alkalies, double salts, many of which are soluble in water. Of the salts thus capable of being formed, however, only a limited number appear to be adapted to yield a deposit of bright, reguline, and adherent platinum. The halogen compounds may obviously be prepared more conveniently by the direct solution of the metal in aqua-regia than by the method described; but the oxygen compounds of platinum yield much more satisfactory results.

Of the salts that may be formed from platinic hydrate by solution in acids (and in part by suitable combination with the corresponding alkaline compounds to form double salts), three only may be named as sufficiently useful to yield practically valuable results in plating. These are the phosphates, oxalates, and acetates, of which also it is practicable to form double salts with the alkalies, soda, potassa, and ammonia, which yield bright, reguline, and adherent plating.

Oxalic acid, of all the oxygen acids, is the best solvent of platinic hydrate, dissolving it even in the cold, but with great energy when aided by heat, and forming platinous oxalate with evolution of carbonic anhydride. From this brownish-black or deep blue solution (according to concentration), brilliant reddish-brown scales of the salt separate abundantly and readily from the hot saturated solution. A saturated aqueous solution of the simple oxalate prepared from the hydrate as above described will yield bright, reguline, adherent platinum when electrolysed with a comparatively weak current, with evolution of carbonic anhydride at the anode. With a stronger current hydrogen also appears at the cathode. This bath may be maintained indefinitely at normal metallic strength by observing the precaution to add oxalic acid and platinic hydrate in small quantities from time to time; or by keeping constantly at the bottom of the bath some platinic hydrate, and adding oxalic acid in crystals or powder from time to time as may be required to keep the bath saturated; or, what is much to be preferred, making a supply of platinous oxalate from platinic hydrate in the manner previously described, and keeping an excess of this present in the bath at all times. This bath has the same advantages that are possessed by the above-described alkaline platinate baths, of being capable of indefinite maintenance at normal metallic strength, and of introducing no substance that will cause its deterioration by the formation of secondary decomposition products.

Phosphoric acid also is a solvent of platinic hydrate. A dilute aqueous solution of this acid will dissolve a small quantity of the metallic hydrate in the cold, and a much larger quantity when aided by heat. With increasing concentration, the solvent power of this acid for platinic hydrate is correspondingly increased. The resulting solution of platinum phosphate, according to the degree of concentration, will be wine-yellow to cherry-red in colour, and with a comparatively weak current will yield bright, reguline, and adherent platinum on metallic surfaces properly prepared to accept the same. The electrolysis of this compound, also, does not involve the formation of deleterious secondary products, the result of the operation being the separation of the metal at the cathode and of the acid radical at the anode—and of the elements of water which are evolved as gases respectively from anode and cathode. In the operation of the bath, therefore, it will become more and more acid as the metal is withdrawn by the accumulation therein of the phosphoric acid set free at the anode. The maintenance of the metallic strength of the bath, therefore, may be effected as in the foregoing cases by having present therein at all times a small quantity of platinic hydrate, or by the addition at the end of each day's work of the quantity of the metallic hydrate which will be required to restore the amount of metal withdrawn. This bath must be worked very acid, and the solution of the platinic hydrate to maintain the strength of the bath must be facilitated by heating, as the solvent power of phosphoric acid for platinic hydrate is much inferior to that of oxalic acid. The double phosphates of platinum with certain of the alkalies may be formed, which will be capable of yielding a deposit of bright, reguline, and adherent metal, and of being maintained approximately at normal metallic strength in the same manner as set forth above. The best results have been obtained with the ammonio-platinic phosphate, prepared by adding to the solution of platinic hydrate in phosphoric acid sufficient aqua ammoniæ to cause the same to give an alkaline reaction, which point will be indicated by the formation of a greyish precipitate that will not disappear on stirring; then restoring the acidity of the solution by adding free phosphoric acid in excess, upon which the precipitate readily dissolves. The resulting solution is yellowish or brownish, and yields superb plating: though, on account of the greater difficulty of maintaining its metallic strength by the solution of the hydroxide, it is not so well adapted as the oxalate for the work of electro-deposition on the large scale. The sodio-platinic phosphate, formed in a manner precisely analogous to the ammonia compound just described, will also yield bright, reguline, and adherent plating; but the soda salt is less freely soluble than the corresponding ammonia compound, and consequently more difficult than the latter to maintain of normal metallic strength.

Platinic hydrate is only very sparingly soluble in strong acetic acid, and it is impracticable to facilitate the solution by boiling, since by persisting in this for a very short time the hydrate is decomposed, and black platinic oxide is formed, which is quite insoluble in this menstruum. However, an alkaline acetate bath may be prepared by the addition to the alkaline platinates above described, of as much acetic acid as may be introduced without causing the formation of a permanent precipitate. But although the appearance and quality of the plating obtained with this bath leave nothing to be desired, the bath does not meet the requirements in respect of indefinite maintenance in normal metallic strength and uniform composition. This difficulty becomes less pronounced as the bath is made more strongly alkaline, when it approximates more closely to the alkaline platinates; for it is obvious that in the presence of a large amount of free alkali, this would unite with the acetic acid to form a simple acetate. The resulting solution would no longer contain sodio-(potassio)-platinic acetate, but sodic (potassic) acetate, sodic (potasic) platinate, and free alkali. Nevertheless, the presence of acetic acid in such alkaline bath appears favourably to influence the quality of the plating yielded, giving the deposited metal a whiteness approaching that of silver; and since furthermore, acetic acid yields only the elements of water and volatile compounds when electrolysed, and therefore does not contaminate the electrolytic bath by forming deleterious secondary products, its judicious addition to the above-described alkaline platinate baths presents some advantages.

The foregoing comprise the compounds found to yield the most satisfactory results in platinum plating.

Directions for Preparing the Electroplating baths.—For the alkaline platinate bath, the following directions may suffice:—Platinic hydrate, 2 oz.; caustic potassa (or soda), 8 oz.; distilled water, 1 gal. Dissolve one half of the caustic potassa in 1 qt. distilled water; add to this the platinic hydrate in small quantity at a time, facilitating solution by stirring with a glass rod. When solution is effected, stir in the other half of alkali dissolved in 1 qt. water; then dilute with enough distilled water to form 1 gal. of solution. To hasten solution, the caustic alkali may be gently heated; but this is not necessary, as the platinic hydrate dissolves very freely. This solution should be worked with a current of about two volts, and will yield metal of an almost silvery whiteness upon polished surfaces of copper and brass, and quite freely. There should be slight, if any, perceptible evolution of hydrogen at the cathode, but a liberal evolution of oxygen at the anode. The addition of a small portion of acetic acid to this bath improves its operation where a heavy deposit is desired. The anode may be of platinum or carbon, and owing to the readiness with which the metal is deposited, an excess of anode surface is to be avoided. Articles of steel, nickel, tin, zinc, or German silver will be coated with black and more or less non-adherent platinum; but by giving objects of these metals a preliminary thin electro-deposit of copper in the hot cyanide bath, they may be electro-platinised in the alkaline platinate bath equally as well as copper. The bath may be worked hot or cold; but it is recommended to work it at a temperature not exceeding 100° F. It may be diluted to one-half the strength indicated in the formula, and still yield excellent results. The surface of the objects should be highly polished by buffing or otherwise prior to their introduction in the bath, if the resulting deposit is designed to be brilliant.

The deposition of platinum takes place promptly. In 5 minutes a sufficiently heavy coating will be obtained for most purposes. The deposited metal is so soft, however, that it requires to be buffed very lightly. A heavier deposit will appear grey in colour, but will accept the characteristic lustre of platinum beneath the burnisher.

The oxalate solution is prepared by dissolving 1 oz. platinic hydrate in 4 oz. oxalic acid, and diluting the solution to the volume of 1 gal. with distilled water. The solution should be kept acidified by the occasional addition of some oxalic acid. The simplest plan of using this bath, and which requires no attention to proportions, is simply to work with a saturated solution of the oxalate, keeping an undissolved excess always present at the bottom of the vessel. An addition of a small quantity of oxalic acid now and again will be found advantageous. The double salts of oxalic acid with platinum and the alkalies may be formed by saturating the oxalate of the desired alkali with platinic hydrate, and maintaining the bath in normal metallic strength by the presence of an undissolved residuum of platinous oxalate.

The double oxalates are not so soluble n water as the simple salt. The oxalate baths, both of simple and double salts, may be worked cold or hot (though not to exceed 150° F.), with a current of comparatively low pressure. The metal will deposit bright, reguline, and adherent, on copper and brass. Other metallic objects must receive a preliminary coppering as above. The deposited metal is dense, with a steely appearance, and can be obtained of any desired thickness.

The deposit obtained in the oxalate baths is sensibly harder than that from the alkaline platinate bath, and will bear buffing tolerably well.

The phosphate bath may be prepared by the following formula:—

Phosphoric acid, syrupy (sp. gr. 1·7)..	.. 8 oz.
Platinic hydrate	.. 1–1½ oz.
Distilled water	.. 1 gal.

The acid should be moderately diluted with distilled water, and the solution of the hydrate effected at the boiling temperature. Water should be added cautiously from time to time, to supply that lost by evaporation. When solution has taken place, the same should be diluted with sufficient water to make the volume 1 gal. The solution may be worked cold or warm to 100° F., and with a current much stronger than that required for the platinates and oxalates. The ammonio-(and sodio-) platinic phosphates may be formed from the simple phosphate by carefully neutralising the solution of the phosphate with ammonia (or soda); then adding an excess of phosphoric acid, or enough to dissolve the precipitate formed, and an additional quantity to ensure a moderate amount of free phosphoric acid in the bath. The phosphate baths will be maintained of normal strength by additions of platinic hydrate, the solutions of which will have to be assisted by heating the bath, preferably at the close of each day's work. The metal yielded by the electrolysis of these phosphate solutions is brilliant and adherent. It has the same steely appearance as that exhibited by the oxalate solutions, but to a less pronounced degree. The physical properties of the deposited metal are in other respects like those described in connection with that obtained from the oxalate baths.

(*h*) On Glass.—The following method of depositing brilliant films of platinum on glass was described recently at a meeting of the London and Provincial Photographic Association, when samples were shown. The method is that devised by Prof. Böttger. In order to succeed in coating porcelain or glass with a perfectly faultless film of platinum, of the brilliancy of silver, it is indispensably requisite to make use of perfectly dry platinum chloride, which must be as free from acid as possible. To that end pour some oil of rosemary over the perfectly dry platinum chloride in a small porcelain mortar, and knead it up with the pestle, renewing the oil about three times, and continue this operation until at length there is produced from the brownish-red chloride a soft plaster-like mass, the colour of which is as black as pitch, and wherein no particles of undecomposed platinum chloride are discoverable. The oil of rosemary assumes hereby a more or less yellow colour, in consequence of its partially taking up chlorine from the platinum chloride. When at length we have arrived at converting the whole of the platinum chloride into the black plaster-looking mass spoken of, rub it well up with the pestle, after pouring the oil of rosemary off, with about five times its weight of oil of lavender, and continue to do so until it has become a perfectly homogeneous thin fluid. It must then be left to stand for ½ hour or so, for it is not until after that interval that it can be used with advantage for platinising. For the production of the brilliant platinum film, all that is now required is to apply the mass as uniformly as may be, and in the thinnest possible coat, to the objects of porcelain, earthenware, or glass by means of a soft delicate brush. The thinner the coat of the above described preparation, the more brilliant the film of platinum subsequently proves. When, in fine, the articles have been gone over as thinly as possible with the fluid conformably with these instructions, all that is required further is to subject them for a few minutes to a very low, scarcely-perceptible red heat, either in a muffle, or in the flame of a Bunsen's gas blow-pipe used with caution. The articles receive from this baking (supposing always that the temperature described has not been exceeded), without requiring any subsequent treatment, an incomparably beautiful lustre, as brilliant as silver. If, by any oversight, the coating of platinum upon the articles has turned out faulty, or in the case of breakages occurring during the baking, every trace of the metal may be recovered with facility, from the objects that have suffered, by means of the following very simple galvanic process, without being obliged to have recourse to the use of aqua regia. Nothing more is required than to pour common hydrochloric acid over them, and then touch them with a zinc rod. On doing this, as quick as lightning, in consequence of the hydrogen evolved both at the upper and lower surface of the film of platinum, which acts as the negative pole, we see the shining metallic coating peel off in the form of infinitely thin leaves from the base of porcelain or glass, and, notwithstanding the specific gravity of the metal, ascend partially and float on the surface of the acid. On separating the hydrochloric acid by the use of a filter, the whole of the platinum, which would be otherwise lost, is recovered, so that no complaint arises as to the waste of any of the metal in question. Prepare at once only as much of the platinising fluid as is required for the day's use, inasmuch as it loses in efficiency by keeping. That which forms the active principle in the fluid, which results from treating platinum chloride with oil of lavender, as above described, is an organic platinum salt, which, in point of fact, one can obtain, after some time, in the form of small elongated octohedral crystals, of a pale yellowish colour, by washing out carefully with alcohol a tolerable quantity of the fluid. The crystals have the property of taking fire with a brilliant flame on being brought near a lighted candle, leaving a residue of compact platinum of dazzling whiteness.

Silver Deposits.—The silver found in the trade, even under the name of virgin silver, retains traces of copper. Silver is purified by several methods:—(*a*) The impure metal is dissolved by nitric acid, and the solution being largely diluted with water, add to it an excess of a filtered solution of common salt. An abundant white precipitate of silver chloride is produced, which rapidly settles to the bottom of the vessel. All the silver salt is decomposed when the clear liquid is not rendered turbid by a further addition of salt. The silver chloride is collected, and washed several times, until the liquors are no longer coloured brown by yellow prussiate of potash. This is the proof that all the copper has been washed out. The washed silver chloride is mixed with two or three times its own weight of soda carbonate, dried, and melted in a crucible. After cooling, the metal is found in a conical button at the bottom of the crucible. To granulate it, the molten silver is poured from a height of about 3 ft., into a large volume of water.

(*b*) The alloy of copper and silver is dissolved in nitric acid, and the solution is evaporated until the salts fuse. After cooling, the fused mass is gradually thrown into a red-hot crucible, when the nitric acid escapes, leaving behind the silver in the metallic state, and the copper as oxide. The separation of the two takes place naturally, and is aided by the addition of dry borax, which dissolves the copper oxide. Silver is easily dissolved in pure nitric acid, but not so rapidly in one contaminated by chlorine or hydrochloric acid, which produces a coat of silver chloride around the metal, and therefore forms an obstacle to its solution. Sulphuric acid also combines with silver, and the resulting salt is but slightly soluble. Pure silver is employed for the preparation of the nitrate and other silver salts, and for soluble anode in silver baths.

Silver Nitrate.—(*a*) Add silver to nitric acid, previously diluted with twice its weight of water, in a flask, and apply a gentle heat until the metal is dissolved; the clear liquor is then separated from any black powder which may be present, evaporated and crystallised. The crystals are dried by exposure to the air, taking care that they do not come in contact with any organic substance.

(*b*) Dissolve the silver in pure nitric acid, and evaporate. The nitrate is yielded in square anhydrous tables. Dissolve this in distilled water, filter, and evaporate again, and the nitrate is obtained pure.

Plating Solutions.—(*a*) Silver nitrate, 1 part; common salt, 1; cream of tartar, 7; powder and mix.

(*b*) Silver nitrate, 1 part; potassium cyanide, 3. Both are applied by wetting with a little water and rubbing on the article to be plated, which must be quite clean. Plating done by the above will be very thin, but it will be silver.

(*c*) Get a glazed earthen vessel, put in 1 oz. nitric acid; place it on a slow fire; it will boil instantly. Throw in some pieces of real silver; this will be dissolved at once. As soon as dissolved, throw in a good handful of salt to kill the acid, then make into a paste with common whiting. The article required to be silvered to be cleaned from grease and dirt, and the paste to be applied with a little water and wash leather. This will keep for years.

(*d*) Silver nitrate, 55 parts; solution of ammonia, 60; soda hyposulphite, 100; precipitated chalk, 100; distilled water, 1000.

(*e*) Dissolve 2 oz. silver with 3 gr. corrosive sublimate; add tartaric acid, 4 lb.; salt, 8 qt.

(*f*) 1 oz. silver nitrate is dissolved in 1 qt. rain or distilled water, and a few crystals of soda hyposulphite are added, which form a brown precipitate soluble in a slight excess of hyposulphite. Small articles of steel, brass, or German silver may be silvered by dipping a sponge in the solution and rubbing it over the surface of the article to be coated. A more concentrated solution may be used for coating parts of articles which have stripped or blistered, by applying it with a camel-hair pencil to the part, and touching the spot at the same time with a thin clean strip of zinc.

Small Bath for Amateurs.—The bath is a cylindrical stoneware, glass, or porcelain vessel. After cleansing and amalgamation, the articles are attached by clean copper wires to the circumference of a brass ring, supported upon the top of the apparatus by 3 or 4 soldered cross wires. The ring is connected with the negative pole of the battery, and the positive pole with a platinum anode, or a cylinder formed of a sheet of silver rolled round, which dips into the middle of the apparatus. The articles must be now and then turned upside down, and sideways, so that each face of the object will be, in turn, directly opposite the silver anode, and thus also the points of contact with the suspending wires receive their quota of metallic deposit. Points, edges, corners and all raised parts, offer a more easy passage to the electric current, and therefore become more coated with metal. As the wear of tablespoons and forks is greater on their convex sides, those parts should face the silver anode longer than the concave portions.

Cold Silvering.—(*a*) 2 dr. tartar, 2 dr. common salt, ½ dr. alum, and 20 gr. silver, precipitated from the nitrous acid by copper. Make into a paste with a little water. This is to be rubbed on the surface to be silvered with a cork.

(*b*) Dissolve pure silver in aquafortis, and precipitate the silver with common salt; make this precipitate into a paste by adding a little more salt and cream of tartar. It is applied as in (*a*).

(*c*) A stoneware or glass vessel is about three parts filled with liquid soda bisulphite; a solution of silver nitrate in distilled water, of medium concentration, is gradually added while the bath is continually stirred with a glass rod; a white flocculent precipitate of silver sulphite is produced by stirring; this is dissolved by the soda bisulphite. The silver solution is added so long as the precipitate readily disappears, and stopped when it becomes slow to dissolve. This bath is always ready to work, and instantaneously produces a magnificent silvering upon copper, bronze, or brass articles which have been thoroughly cleansed and passed through a weak solution of nitrate of binoxide of mercury, although this last operation is not absolutely necessary. The loss of silver is made good by additions of silver nitrate. When the proportion of the bisulphite is not sufficient to dissolve the metallic salt, add some soda bisulphite to restore the bath to its primitive state. Silver is slowly deposited upon the sides of the vessel: this may be dissolved in nitric acid for future uses.

As the bath is cold it is always ready for use, and the deposit is finer and more unalterable, because only chemically pure silver is deposited, without any mixture of subsalts. Bisulphites of potash, ammonia, and other alkalies may be substituted for the soda bisulphite, but the latter is to be preferred because it is cheaper.

(*d*) By rubbing, with the thumb, a cork, or a brush. The results are better than those by the whitening process, but not very durable; the method is useful to repair slight defects upon more durable silverings, and to produce mixtures of gold and silver, or gold, upon slightly gilt objects, thus avoiding the use of resist varnishes. Make a paste by thoroughly grinding in a porcelain mortar or with a muller, and, as far as practicable, not in the light:—(1) Water, 3½–5 oz.; white fused silver nitrate, or, preferably, chloride, 7 oz.; potash binoxalate, 10½ oz.; potash bitartrate, 10½ oz.; common salt, 15 oz.; sal ammoniac, 2¾ oz. (2) Silver chloride, 3½ oz.; potash bitartrate, 7 oz.; common salt, 10½ oz. When finely pulverised in a porcelain mortar, triturate it under a muller upon a plate of ground glass until there is no granular feeling. Keep the paste in a porcelain pot, or in a black glass vessel, to preserve it from the light, which decomposes it rapidly. When about to use it, add a little water so as to form a thin paste, which is applied with a brush or pencil upon the cleansed articles of copper, or upon those gilt by dipping, or even upon those gilt by the battery, provided that the coating is thin enough to allow the copper to decompose the silver paste through the coat of gold; allow the paste to dry naturally, or with the aid of a gentle heat. The chemical reaction is more or less complete, according to the thickness of the gold deposit, and the dry paste is of a pink shade, or entirely green. The salts are removed by a thorough rinsing in cold water, and the silver appears with a fine frosted appearance, the brightness of which may be increased by a few seconds' immersion in a very dilute solution of sulphuric acid, or potassium cyanide. This silvering bears the action of the wire brush and of the burnishing tool very well; and it may also be oxidised. Should a first silvering not be found sufficiently durable, after scratch-brushing, apply a second or a third coat. This silvering is not so adhering or white on pure copper as upon a gilt surface. For the reflectors of lanterns the paste is rubbed upon the reflector with a fine linen pad; then, with another rag, a thin paste of Spanish white, or similar substance, is spread over the reflector and allowed to dry. Rubbing with a fine and clean linen rag will restore the lustre and whiteness of the plated silver.

Preparing Soda Bisulphite for Cold Silvering.— Put into a tall vessel of glass or porcelain, water, 10 pints; crystallised soda carbonate, 10 lb. Pour a little mercury into the bottom of the vessel, so that the glass tube carrying sulphurous acid gas, which has to be placed in it, may not be stopped by the crystals formed during the operation. Arrange an apparatus for the production of sulphurous acid gas, and let the washed gas pass through the vessel holding the soda carbonate. Part of the soda is transformed into sulphite, which dissolves, and a part falls to the bottom as bicarbonate. The latter is, however, transformed into sulphite by a continuous production of sulphurous acid, and the carbonic acid escapes. When all has dissolved, continue the passage of sulphurous acid until the liquid slightly reddens blue litmus paper, and then put the whole aside for 24 hours. After that time some crystals are found upon the mercury, and the liquid above, more or less coloured, is the soda bisulphite for silvering. The crystals are separated from the mercury, drained, and kept for gilding baths. They are not suitable for silvering. The liquid soda bisulphite should be stirred with a glass rod, to throw off the carbonic acid which may still remain. The liquor should then be again tried with blue litmus paper. If it turns a deep red, add a little soda carbonate for neutralising the excess of sulphurous acid; if red litmus paper becomes blue, there is too much alkali, and more sulphurous acid gas should be passed through the liquid, which is in the best condition when litmus paper becomes violet or slightly red. This solution marks 22°–26° B. and must not come in contact with iron, zinc, tin, or lead.

Hot Silvering.—(*a*) Dissolve 1 oz. silver in nitric acid; add a small quantity of salt; then wash it and add sal ammoniac, or 6 oz. salt and white vitriol; also ¼ oz. corrosive sublimate; rub them together till they form a paste. Rub the piece which is to be silvered with the paste, heat it till the silver runs, after which dip it in a weak vitriol pickle to clean it.

(*b*) For small articles a bath is made by dissolving in an enamelled cast-iron kettle in 2 gal. water, 17½ oz. ordinary potassium cyanide. Also dissolve 5¼ oz. fused silver nitrate in 1¾ pint water contained in a glass or porcelain vessel. The second solution is gradually poured into the first. Stir with a glass rod. The white or greyish-white precipitate produced soon dissolves, and the remaining liquor is filtered if a perfectly clear bath is desired. When brought to the boiling-point, it will immediately silver the cleansed copper articles plunged in it. The objects must be quickly withdrawn. The silvering should immediately follow the cleansing, although the rinsings after each operation should be thorough and complete. This bright and light silvering is adapted for set jewellery, which cannot be scratch-brushed without flattening the clasps, and to which a bright lustre is absolutely necessary as a substitute for the foil of burnished silver placed under the precious stones of real jewellery. The employment of the solution of nitrate of binoxide of mercury is useless, and even injurious, for this bath. It is useless to keep up the strength of the solution by new additions of cyanide and silver salt; thus reinvigorated, it gives results far inferior to those of the former solution. The bath should, therefore, be worked out as long as the silvering is satisfactory, and when exhausted, put away with the waste. With this process a battery and a soluble anode may be used to obtain a more durable deposit.

(*c*) A solution which, when boiling, produces a very fine silver coat, with a dead, or partly dead, lustre, upon cleansed coppers, is made by dissolving with the aid of heat, in a well-scoured copper kettle, distilled water, 9 pints; potassium ferrocyanide, 21 oz.; potash carbonate, 14 oz. When the liquid boils, add the well-washed chloride obtained from 1 oz. pure silver. This should boil for about ½ hour, and be filtered before using; part of the silver deposits upon the copper kettle, and should be removed when a new bath is prepared. On account of this inconvenience, the process has been nearly abandoned, although the products are remarkably fine. All the dipping silvering baths, which contain a comparatively great excess of potassium cyanide to the proportion of the silver salt, will silver well copper articles perfectly cleansed, even in the cold; whereas this property diminishes in proportion to the increase of the amount of silver in the bath, or with the decrease of the amount of cyanide.

(*d*) For small articles, partly copper and partly iron, such as those used for saddlery and carriage wares, a particular process of silvering is used. The bath is composed of:—Water, 9 pints; caustic potash, 6 oz.; potash bicarbonate, 3½ oz.; potassium cyanide, 2 oz.; fused silver nitrate, ⅔ oz. The cyanide, caustic potash, and bicarbonate are dissolved in 7 pints of water in an enamelled cast-iron kettle, then the remaining quart of water, in which the silver nitrate has been separately dissolved, is added to the former solution. For the silvering operations, the articles are cleansed, thoroughly rinsed, and put into a small enamelled kettle. Enough of the silver bath is poured in to cover the articles entirely, and the whole is brought to a boil for a few seconds, and stirred with a wooden spatula. When the silvering appears satisfactory, the liquor employed is put with the saved waste; the same liquid is never used for two batches of articles. This process gives a somewhat durable silvering with a dead lustre, of a greyish-white, which is increased in whiteness and brightness by soap and burnishing.

Silvering with Foil.—This method is never practised except upon objects already manufactured, in their definite shape; and is adapted to all kinds of copper, bronze, or brass. It is, in certain respects, superior to plated silver; but is very difficult of execution, and has less adhesion to the metal underneath. After annealing the articles, they are thrown whilst hot into a bath of sulphuric acid with a small proportion of hydrochloric and nitric acids. They have then a dull and dead lustre, owing to a multitude of small holes, which are so many points of attachment for the silver foil. The objects, thus prepared, are tightly fixed upon an iron rod, which is held in a vice. Their temperature is raised to about 300° F., by means of incandescent charcoal put at the proper place, so as to open the pores of the metal, which, by cooling afterwards, will imprison the silver applied. The silver foils, taken from the book with small tweezers, are cut to the proper size upon a cushion with an ivory or steel knife. After each foil is deposited upon the object, it is made to adhere by a light pressure of a rag pad, and afterwards by the friction of a steel burnishing tool. The parts of the silver foil which do not adhere are removed with a soft brush. Gold-beaters prepare silver foil either with bright or dead lustre. The latter is made to adhere only by the pressure of the pad, and not by the burnishing tool. This dead lustre cannot compare in fineness with that obtained by the battery; however, it resists handling and the sulphur gases of the atmosphere better. Articles thus silvered are only burnished after all the silver foils have been applied; round or cylindrical objects are burnished upon the lathe, other forms by the hand; there are always places and lines showing the vibrations of the burnishing tool. This method of silvering is only employed for very large objects, such as high chandeliers and other church ornaments. Spoons and forks may be covered with silver foil as follows:—First slightly silver with a dead lustre in a silver bath by dipping; heat; and then cover with silver foil, by the pressure of an iron scratch-brush striking vertically, forcing the silver foils into the pores of the metal underneath. Burnish by the usual method; it is impossible to obtain a dead lustre by this method.

Whitening with Silver in a Pot.—This operation is still employed for whitening small wares for which durability is of secondary importance, and which simply require the whiteness of silver; such as hooks and eyes, or buttons. This whitening is made as follows:—(*a*) Dissolve a certain quantity of pure granulated silver in double its weight of pure nitric acid. The solution is largely diluted with water, and the metal is precipitated in heavy white clods by common salt or hydrochloric acid. All the silver nitrate has been decomposed when a further addition of hydrochloric acid or common salt to the clear supernatant liquid does not produce any turbidity. The clear liquors are then thrown away, and the silver chloride obtained is washed several times, to deprive it of all free acid. If this precipitate is to be kept some time before use, it should be removed from the sunlight, which blackens it rapidly. The silver chloride, with a little water, is thoroughly mixed with at least 80 times its weight of finely powdered potash bitartrate, and kept in a stoneware pot.

(*b*) Pure silver for making the chloride, 1 part; powdered cream tartar, salt, 83 parts each; a few spoonfuls of the paste thrown in, and dissolved in boiling water contained in a pure copper kettle. The articles are dipped into this bath by a hook, or in a basket of wire gauze. Or have another basin of copper, shallow and perforated with holes, which rests against the upper sides of the kettle. By means of handles, this basin can be removed at once with its contents. Stir the articles with a wooden spatula; and at each operation add a quantity of paste, proportioned to the surfaces to be whitened. These baths do not work well when freshly made, but improve as they are more used. They acquire a dark green tint, due to the copper which is dissolved, and which takes the place of the deposited silver. Varnishing, colouring, and cleansing may be done in aquafortis; but these cleansing methods are inferior to those employed for gilding; in general, use the worn-out acids of gilders. Brighten the articles by friction with saw-dust. The smallest particle of iron, zinc, or tin introduced into the whitening bath imparts a red colour to the brass or copper articles in the liquor. The iron is separated by a magnet; the zinc is dissolved in pickles of hydrochloric or sulphuric acid, which, when cold, do not sensibly corrode the copper articles; tin or lead must be picked out by hand. If the operation has not succeeded, the articles are plunged for a few seconds into a boiling solution of water, 2⅕ gal.; silver nitrate, 3½ oz.; ordinary potassium cyanide, 21 oz. This bath retains its strength for a long time, and increases the brightness and whiteness of the deposit. The process of silvering by dipping has nearly superseded this method.

Silvering Powder.—(*a*) Take 40 gr. silver dust; cream of tartar, 3 dr.; common salt, 2 dr.; and 40 gr. powder of alum. Polish any silver articles with this powder and a soft leather.

(*b*) Silver nitrate, 30 gr.; common

salt, 30 dr.; cream of tartar, 3½ dr. Mix, moisten with water, and apply.

Plated Silver is obtained by rolling together a plate of copper of the first quality, and one of silver; these are either welded, or simply united by placing their hot and clean surfaces together, wetted with a concentrated solution of silver nitrate. The two metals are reduced and drawn out about equally by the pressure of rolls, and long sheets or bands of silvered metal are thus obtained, with which a great many articles may be manufactured. By this mode of operation, a great quantity of material is lost, as the objects have to be cut out from a sheet entirely silvered, and the waste retains a large proportion of that metal; the cut sections present parts without silver, which must be hidden by ledges, or by silvering by another method. There is also the absolute necessity of employing pure copper, which is more costly, less sonorous, and not so tough as its alloys; but the greatest defect of the process is the difference of thickness of the silver, according to the shape of the object. Raised surfaces are the most exposed to friction, and it is just there that the coat of silver is the thinnest; the conditions are reversed with electro-silvering, and the parts in relief receive a more abundant deposit of silver, which is a satisfactory result. The best plated silver is manufactured by applying upon an ingot of pure copper weighing 9 parts, another ingot of pure silver weighing 1 part, to coat one side only; add another part of silver, if it is intended to coat both sides. The two are rolled together until the desired thickness is obtained. The silver of the plated metal will be bright if the rollers are well polished, and dull with rough rollers. The only solder which does not injure plated silver is tin solder; and when the objects manufactured are required to resist a warm temperature, nuts and screws are employed. The electroplating of old wares made from copper with a covering of silver, is often difficult. Supposing it is required to electroplate an old cruet-stand, the bottom is separated from the wire, either by unsoldering or unscrewing. Smooth by emery cloth, or pumice and water, or by powdered bath-brick brushed over with a hard brush. Spots of verdigris are removed with a few drops of hydrochloric acid. The great difficulty consists in giving a good electro-deposit upon the edges or mounts where there may be some lead or lead solder; apply to such parts, with a rather soft brush, a solution made by dissolving 4 oz. mercury in nitric acid, and adding about ½ pint cold water. This solution is lightly brushed over the lead mounts only; the article and brush are then well rinsed, and the brush and plain water are applied in the same way. The solution of mercury will turn the edges black, or dark grey, but the subsequent brushing will render them bright again. The frame when well rinsed is ready for the depositing bath. If, on its first immersion, any black spots appear, the frame may be removed, again brushed over, and finally returned to the bath. If the edges do not receive the coating of silver as readily as the other parts, the solution may require a little more cyanide, or a greater battery power, or an increase in the surface of the anode. These lead edges may be prepared for receiving the silver deposit by a previous coat of copper applied as follows—The edges are plunged into a solution of copper sulphate, with a little free sulphuric acid in it; then, by touching the lead edge with an iron wire, it is immediately coated with a bright deposit of copper, which is rinsed and becomes a good conductor for the further electro-deposit of silver. The coating of tin underneath the bottom of cruet frames is very difficult to plate, unless in a solution made expressly for it; therefore it is preferable to remove it either with abrading materials, or with nitric acid employed with care. This process of depositing copper will be found useful not only for old plated ware, but also for many articles on which are found unruly spots of tin solder.

Ascertaining Weight of Silver Deposited.—(*a*) The articles are cleansed, dried, and weighed in a scale. However rapidly this may be done, the surface of the copper will be slightly oxidised and tarnished; to recover their former cleanliness, the articles must be plunged into a strong pickle of sulphuric acid, and then into the mercurial solution. After rinsing, and immersion in the bath, practical experience will teach when it is nearly time to withdraw the articles from the solution. They will have to be weighed several times before the intended weight of silver has been deposited.

(*b*) Cleanse the articles, and put them immediately into the bath, except one, which is treated as above, and used as a test. This piece is now and then removed from the bath to ascertain its increase of weight, and when it has acquired its proportion of silver it is supposed that the other pieces are also finished. Strongly amalgamated articles will not become sensibly oxidised during the drying which precedes their weighing. When the objects have been dried in order to ascertain the proportion of deposited silver, they should not be returned to the bath without having been cleaned in a hot solution of potash cyanide, which dissolves the grease from the handling, and passed again through the solution of nitrate of binoxide of mercury, and rinsed. Alcohol may be substituted for the hot solution of cyanide, but the results are not so sure, and the expense is greater. Both these methods are tedious, and only give approximate results.

(*c*) Remove one dish of an ordinary pair of scales, substitute for it a metallic frame which supports the articles to be silvered, and communicates through the beam and the column with the negative electrode of a battery; connect the soluble anode with the positive pole. When the articles are suspended to the frame, and are in the bath, the equilibrium of the scale is established by weights upon the other dish; add to this a weight equal to the silver it is desired to deposit. The operation will be finished when the equilibrium of the beam is re-established. This method is not mathematically accurate, but is sufficiently exact for all practical purposes. An automatic arrangement, by which the electric current may be broken at the time the articles in the bath have received a sufficient deposit of silver, is easily arranged, and saves time and metal.

Electroplating Bath.—Water, 2⅕ gal.; potassium cyanide, pure, 17½ oz.; pure silver for cyanide, 8¾ oz. The composition of commercial potassium cyanide is exceedingly irregular. The pure, or No. 1, contains 90-100 per cent. real cyanide, and is especially employed for gilding and silvering baths. No. 2 contains 60-70 per cent. real cyanide; it is the article prepared by Liebig's method, and is used for electro-baths of copper and brass. No. 3, which marks 55-60 per cent., is for scouring and preparing baths, and for photographic operations. (*a*) Put in a porcelain dish, holding a quart, pure granulated silver, 8¾ oz.; pure nitric acid at 40° B., 17½ oz. Heat by charcoal or gas. The dish should be supported by an iron triangle, and not in direct contact with the fire. The acid rapidly attacks and dissolves the silver, with an abundant production of yellow nitrous vapours, which must not be inhaled. When the vapours have disappeared, there remains a liquid more or less colourless, according to the proportion of copper held by the commercial silver, which is seldom entirely pure. The heat is then increased in order to evaporate the excess of acid, which escapes in white fumes. The material in the dish swells up and dries, and, with a further increase of heat, melts like wax. The dish is then removed from the fire, and being held with a cloth, the molten mass is made to flow upon the sides, where it soon solidifies; the fused silver nitrate (lunar caustic) is more or less white, or grey, according to the purity of the silver employed. When perfectly cold, turn the dish upside down, and by a gentle tap on the sides, the mass is detached.

(*b*) Dissolve the silver nitrate in 10-15 times its weight of distilled water; hydrocyanic acid poured into this solution immediately produces an abundant white precipitate of silver cyanide. A sufficient quantity of prussic acid has been employed when, by adding a few drops of it to the clear liquid, no precipitate or turbidity appears. Throw the liquid upon a filter of calico stretched on a wooden frame: the silver cyanide remains on the cloth, the solution with the nitric acid and excess of prussic acid passes through. Wash the precipitate left upon the filter two or three times with pure water.

(*c*) The silver cyanide is put into the vessel intended for the bath, and stirred with the $2\frac{1}{5}$ gal. water. The potassium cyanide is then added, dissolves it, and also dissolves the silver cyanide, thus giving a solution of a double potassium and silver cyanide. Those who employ small baths, often renovated, may substitute for the silver cyanide the chloride or the nitrate of this metal. In the latter case, the quantity of potassium cyanide should b increased. Such baths will be prepared as follows:—

(*d*) The silver nitrate is prepared in the manner indicated above, and $5\frac{1}{4}$ oz. of it, nearly equal to $3\frac{1}{2}$ oz. pure silver, are dissolved in $2\frac{1}{5}$ gal. water.

(*e*) The potassium cyanide No. 1, about $8\frac{3}{4}$ oz., is then added. Stir to facilitate the solution, filter the liquor, to separate the iron contained in the cyanide. This operation may in some cases be dispensed with, because the iron rapidly falls to the bottom of the bath, and the solution becomes limpid. The proportion of potassium cyanide employed is more than is required for dissolving the silver, as $1\frac{1}{2}$ part good cyanide is sufficient for 1 part silver; but unless there is an excess of potassium cyanide, the liquors do not conduct electricity well, and the deposit of silver is granulated and irregular. The silvering is effected with a battery, and with baths either warm or cold. The latter method is generally adopted for articles which require great solidity. The hot process is used for small articles, and is preferable for steel, iron, zinc, lead and tin which have been previously electro-coppered. The hot baths are generally kept in enamelled cast-iron kettles, and the articles are either suspended, or moved constantly about in them. The preliminary cleansing in acids, and passing through the mercurial solution, are necessary. A somewhat energetic current is needed, especially when the articles are moved about, in order to operate rapidly. There is too much electricity when the articles connected with the negative pole of the battery become grey or black, and produce many bubbles of gas. A platinum, large wire or thin foil anode, is generally preferred to the soluble anode of silver employed in cold baths, but the solution is rapidly impoverished. In hot silvering baths, the separate battery is often replaced by a zinc wire wrapped around the articles. The points of contact of the two metals are black or grey, but the stain disappears by plunging the object into the liquor for a few moments, after it has been separated from the zinc, and carefully scratch-brushed. Instead of separate batteries, a simple apparatus may be made of a glass, porcelain, or stoneware vessel holding the bath, and in the centre of which is a porous jar filled with a solution of 10 per cent. potassium cyanide or common salt. The zinc cylinder, immersed in this porous jar, carries a larger circle of brass wire, the cross diameters of which are soldered to the zinc. This brass ring projects over the bath, and the articles, suspended to the ring by slinging wires, hang down into the bath. At the beginning, the operation goes on rapidly, and the deposi is good; but, after a time, the solution of zinc traverses the porous cell and impairs the purity of the bath. An impoverished hot bath is reinvigorated by additions of equal parts potassium cyanide and silver salt. It is necessary to replace the water in proportion as it is evaporated. When the silver baths rapidly deposit metal without the aid of electricity, it is a proof that they are too rich in cyanide, or too poor in silver. A deposit effected under such conditions is rarely adhering, especially when upon articles previously coppered, because the excess of cyanide dissolves the deposited copper, and the silver which takes its place may be removed with the finger.

The remedy consists in adding to the bath only enough silver salt and no more, so that a piece of copper will not become sensibly silvered in it, without the aid of electricity. The cold electro-silvering baths generally employed for electroplating such articles as table-spoons or forks are contained in large rectangular wooden troughs lined with gutta-percha, or made of riveted wrought iron. They are sufficiently high to allow about 4 in. of liquid above the immersed object, whose distance from the bottom and sides should be nearly the same, to give a regular deposit of metal at both extremities of the object. The upper ledge of the trough carries two brass rods all round, which do not touch one another, one above the other, so that other metallic rods, being put across, will rest upon the higher or the lower rod, but not both at the same time. Each rod is connected with one of the poles of the battery by conducting wires, the points of contact of which should be perfectly clean. The rod which supports the articles to be silvered is connected with the negative pole represented by zinc in most batteries; and the other, supporting the anodes, is attached to the positive pole, which is carbon with Bunsen's elements, copper for Daniell's, and platinum with Grove's cells. A certain number of spoons and forks fixed to a rod, by means of copper wires, are cleansed at the same time, and the rod is placed upon the negative conducting rod of the trough. Then, facing these articles, hang upon the positive conducting wire of the trough another metallic rod to which the soluble silver anode is attached like a flag. Next comes another series of spoons and forks, faced by another soluble anode, in such a manner that each row of spoons and forks is between two anodes. The articles to be silvered all rest upon the negative conducting rod, and the soluble anodes upon the positive one. This disposition is for obtaining an equal deposit upon all the pieces. The objects require turning upside down during the operation; in order to prevent a thicker deposit on the lower parts, as the richest part of the solution is the densest, and therefore lies near the bottom of the trough. The denser layers, being richer in metal, deposit it more abundantly upon the direction which they follow, and form grooves which cannot be filled by the lighter and poorer currents. It is, therefore, advantageous to keep the objects in constant motion. In this case the frame supporting the articles does not rest upon the trough, but is suspended above the bath, and receives its motion from a small eccentric, or other motive power. The silver deposit will adhere strongly if the articles have been fully amalgamated in the solution of nitrate of binoxide of mercury, and have remained in the silver bath 12–15 hours, according to the intensity of the current. The silvering will be the better and finer as the intensity of the current is weaker, up to a certain limit. A sufficient quantity of silver may be deposited in 3–4 hours, but the result is not satisfactory, and the burnishing is very difficult. When the articles have acquired a film of silver, they are sometimes removed from the bath and thoroughly scratch-brushed, cleansed in alcohol, or, preferably, in a hot silvering bath, thence again passed through the mercurial solution, and finished in the former cold electro-bath. This first scratch-brushing, which is not always necessary, obviates the tendency of certain alloys to assume a crystalline appearance, and corrects imperfections of the cleansing process. Electro-silvering baths do not generally work so well when freshly prepared as when they have been used for a certain time; the deposit is often granulated, bluish, or yellowish. It is therefore desirable to mix a portion of old liquors with those recently prepared, or new baths may acquire an artificial age by boiling them for a few hours, or adding to them one or two thousandths of aqua ammonia.

Resists and Reserves.—By reserves, certain parts of a metallic article, which may be already covered with an electro-deposit on its whole surface, are coated with another metal. To gild the parts in relief of an object of which the body is silvered, make a gold reserve, and use a silver reserve for silvering of certain parts of a body already gilt. This requires a little practice and care, and a firm hand to make thin lines with the hair pencil. Thoroughly scratch-brush and wipe the object; the parts intended to have the primitive colour must be covered by a brush with a resist varnish; dry in the air, or in a stove, or upon a gentle fire until it no longer feels sticky. Place in the bath; the galvanic deposit will only coat those parts unprotected by the varnish. The temperature of the bath should be low, and the current weak, for fear of having rough lines where the deposit touches the varnish, from the latter becoming softened, or from bubbles which are disengaged at the negative pole under the action of a strong electric current. When the deposit is completed, remove the resist varnish with warm essence of turpentine, and afterwards with tepid alcohol; gaseline or benzole are preferable, as they rapidly dissolve in the cold nearly all resinous and fatty bodies, or the varnish may be destroyed by a brief immersion in concentrated sulphuric acid when cold. It often happens that several colours and metals have to be placed upon the same object, such as silver with both a bright and a dead lustre, and yellow, green, red, white, or pink golds, or platinum. Varnishes are also employed for avoiding the deposit of the precious metals upon those parts which do not need them.

Resist or Reserve Varnishes.—Dissolve in boiled linseed oil or essence of turpentine, rosin, or copal; these varnishes are not sufficiently coloured to distinguish the places where they have been laid on, mix with them therefore a certain proportion of red-lead, chrome yellow, or Prussian blue, which at the same time facilitates their drying.

Anodes.—Should the anodes become black during the passage of the electric current, the solution contains too little potassium cyanide and too much silver. In this case the deposit is adherent, but too slow, and the bath loses more silver than it can gain from the anodes. Carefully add sufficient potassium cyanide. If the anodes remain white during the current, the proportion of potassium cyanide is too great, the deposited silver is often without adherence, and the anodes lose more metal than is deposited; add silver salt until it dissolves with difficulty. When in good working order the soluble anodes become grey during the passage of the electricity, and white when the circuit is broken. The specific gravity of the bath may vary from 5° to 15° B. for salts, and still furnish good results. There is a simple and rapid process for ascertaining the state of the bath, and establishing the proper ratio between the silver and the cyanide. About $\frac{1}{2}$ pint of the liquor is put into a tall glass, and a solution of $\frac{1}{3}$ oz. silver nitrate in 3 oz. distilled water is poured into the former, drop by drop. If the white precipitate produced is rapidly dissolved by stirring, the liquor is too rich in cyanide, or too poor in silver; should the precipitate remain undissolved after long stirring, the liquor is too rich in silver and too poor in potassium cyanide. When the precipitate is dissolved but slowly, the liquor is in the best condition.

Frosted Silver.—Dip the article in a solution of nitric acid and water, half and half, for a few minutes, then wash well in clean water, and dry in hot sawdust. When thoroughly dry, brush the sawdust away with a soft brush, and burnish the parts required to be bright.

Bright Lustre.—Carbon bisulphide, in small proportion, imparts a bright lustre to electroplated articles. Put 1 oz. carbon bisulphide into a pint bottle containing a strong silver solution with cyanide in excess. The bottle should be repeatedly shaken, and the mixture is ready for use in a few days. A few drops of this solution may be poured into the plating bath occasionally, until the work appears sufficiently bright. The bisulphide solution, however, must be added with care, for an excess is apt to spoil the solution. In plating surfaces which cannot easily be scratch-brushed, this brightening process is very serviceable. Care must be taken never to add too much at a time.

Varnished Silver Leaf.—Use first, prepared ox-gall; next, isinglass; then, alum, to kill the former; finish with hard white lac.

Preventing Electro-silver turning Yellow.—This change of colour is due to the deposit, by galvanic action, of pure silver and of subcyanide, which is rapidly decomposed and darkened by light. It is therefore necessary to remove the subcyanide by one of the following methods:—(*a*) The articles are left immersed in the bath for some time after the electric current has been interrupted, when the silver subcyanide is dissolved by the potassium cyanide.

(*b*) Having smeared the objects with a paste of borax, they are heated in a muffle until the salt fuses and dissolves the subcyanide. This process anneals and softens the metal.

(*c*) The poles of the battery are inverted for a few seconds, that is to say, the articles become soluble anodes, and the electric current carries away the silver subcyanide in preference to the metal; this operation should be very short, otherwise the silver will entirely abandon the objects and will coat the silver sheets.

Burnishing. — By burnishing, the roughness of an object is flattened down until the surface is smooth and polished, like a looking-glass. Burnishing is an important operation for electro-deposits which consist of a multitude of small crystals with intervals between them, and with facets reflecting the light in every direction. The deposited metal is hardened, and forced into the pores of the underlying metal, and the durability is thus increased to such an extent that with the same amount of silver a burnished article will last twice as long as one which has not been so treated. The instruments employed for burnishing are made of different materials, and must be of great hardness and a perfect polish. Such are hardened cast steel, agate, flint, and blood-stone. For metallic electro-deposits, steel and blood-stones are especially employed. There are several qualities of blood-stone; its grain should be close, hard, and without seams or veins; it should leave no white lines on the burnished parts, nor take off any metal, and its colour should be of an intense black-red. The steel must be fine and close grained, and perfectly polished. Should the polish of any burnishing tool alter by use, it is restored by friction upon a skin or leather attached to a wooden block, which is fixed to the bench. The leather is covered with polishing rouge in impalpable powder, or, preferably, with pure alumina obtained by calcining ammonia alum in a forge fire. Venetian tripoli, rottenstone, tin putty, emery, or many other hard substances finely powdered may be employed. The burnishing tools are of various shapes, such as a lance, a tooth, a knife, a half-sphere, or a dog's tongue, and a considerable stock is necessary. The burnishing is divided into two distinct operations; the first consists in roughing, and the second in finishing. The tools for the first have a sharp edge, whilst for the second operation they have a rounded surface. The tools for the hand or the lathe are fixed by copper ferrules into short, round wooden handles, so that the hand is not influenced by their weight; the tools for the arm or the vice are fastened to wooden handles sufficiently long to rest their slender part upon the arm or the shoulder, the stouter lower portion is grasped by the hand. The burnishing tools and the objects must be frequently wetted by certain solutions, some of which facilitate the sliding of the instrument, or with others which have a chemical action upon the shade of the burnished articles. Of the first are pure water, solutions of soap, decoctions of linseed, and infusions of the roots of marsh-mallow or liquorice; the second includes wine-lees, cream tartar, vinegar, alum in water. When burnishing gold applied upon electro-deposits of copper, as in gilding with a dead lustre by that method, use pure water for fear of producing a disagreeable red shade. A solution of green soap is sometimes pre ferred by operators, although when old it imparts an unpleasant tinge, owing to the sulphides of the liquor. When the burnishing is completed, the surface is wiped longitudinally with a soft and old calico rag. The polish obtained by burnishing is called black, when it reflects the rays like a mirror; and should the presence of mercury or a bad deposit prevent the tool from producing a bright surface, the object is said to be greasy. Articles which have been previously polished, and which generally receive a very trifling deposit, are not burnished, but rubbed with chamois leather and the best quality polishing-rouge. Too thick or too rapid electro-deposits cannot be burnished, but must be polished by rubbing with a leather and a mixture of oil and powdered pumice, tripoli, or tin putty. Coarse powders are used at the beginning, and impalpable ones at the end of the operation. Polished silver deposits are more agreeable to the eye than burnished ones; but the hardening of the latter renders them more durable.

Nielled Silver.—This is a kind of inlaid enamel work, and is obtained by the sulphuration of certain parts of a silver object. But instead of being direct, this is produced by inlaying the silver surface with a sulphide of the same metal prepared beforehand. For preparing the niel, heat a certain proportion of sulphur in a deep crucible; heat a certain quantity of silver, copper, and lead in another crucible, and when melted pour into the fused sulphur, which transforms these metals into sulphides; then add a little sal ammoniac, remove from the crucible, pulverise for use. First crucible—flowers of sulphur, 27 oz.; sal ammoniac, 2¾ oz. Second crucible, which after fusion is poured into the first—silver, ½ oz.; copper, 1½ oz.; lead, 2¾ oz.

(*a*) After having reduced the niel to a fine powder, mix with a small proportion of a solution of sal ammoniac, hollow out the engraving upon a silver surface, and cover the whole, hollows and reliefs, with the composition. The article is then heated in a muffle until the composition solders to the metal. Uncover the pattern by a level polish, when the silver will appear as over a black ground. This method is costly, as each article must be engraved.

(*b*) Engrave in relief a steel plate, and press it against the silver plate between two hard bodies. The copy is hollow, and ready to receive the niel. A great many copies may be obtained from the same matrix.

Old Silvering.—To imitate old artistic productions made of solid silver, the groundwork and hollow portions not subject to friction are covered with a blackish-red earthy coat, the parts in relief remain with a bright red lustre. Mix a thin paste of finely-powdered plumbago with essence of turpentine, to which a small proportion of red ochre may be added to imitate the copper tinge of certain old silverware; smear this all over the articles. After drying, gently rub with a soft brush, and the reliefs are set off by cleaning with a rag dipped in spirits of wine. Old silver is easily removed, and the brightness of the metal restored, by a hot solution of caustic potash, potassium cyanide, or benzole. To give the old silver tinge to small articles, such as buttons and rings, throw them into the above paste, rub in a bag with a large quantity of dry fir-wood saw-dust until the desired shade is obtained.

Oxidised Silver.—(*a*) This is not an oxidation, but a combination with sulphur or chlorine. Sulphur, soluble sulphides, and hydrosulphuric acid blacken silver, and insoluble silver salts, and particularly silver chloride, rapidly blackens by solar light. Add four or five thousandths of ammonia hydrosulphate, or of potassium quintisulphide, to ordinary water at a temperature of 160°–180° F. When the articles are dipped into this solution, an iridescent coating of silver sulphide covers them, which after a few seconds more in the liquid turns blue-black. Remove, rinse, scratch-brush and burnish when desired. Use the solution when freshly prepared, or the prolonged heat will precipitate too much sulphur, and the deposit will be wanting in adherence; besides the oxidation obtained in freshly-prepared liquors is always brighter and blacker than that produced in old solutions, which is dull and grey. If the coat of silver is too thin, and the liquor too strong, the alkaline sulphide dissolves the silver, and the underlying metal appears. In this case cleanse and silver again, and use a weaker blackening solution.

(*b*) Oxidised parts and gilding may be put upon the same article by the following method: After the whole surface has been gilt, certain portions are covered with the resist varnish, silver the remainder. Should the process of silvering by paste and cold rubbing be employed, the gilding should be very pale, because it is not preserved, and is deeply reddened by the sulphur liquor. When this inconvenience occurs from a too concentrated liquor, it is partly remedied by rapidly washing the article in a tepid solution of potassium cyanide.

(*c*) Deep black is thus obtained upon cleansed copper:—Dissolve 3–4 oz. blue ashes (copper hydrocarbonate) in a sufficient quantity of aqua ammonia, place the cleansed copper in this solution, cold or tepid; it will be instantaneously covered with a fine black deposit. This coat is so thin that burnished articles look like varnished black.

(*d*) Oxidise silver-plated articles by dissolving copper sulphate, 2 dwt., potash nitrate, 1 dwt., and ammonia muriate, 2 dwt., in a little acetic acid. Apply with a camel-hair pencil; but warm the article first, and expose it to the fumes of sulphur in a closed box; the parts not to be coloured must be coated with wax.

Silvering Brass.—(*a*) Take ¼ lb. potassium cyanide and ½ oz. silver nitrate; dissolve all the cyanide in 16 oz. distilled or boiled water, and the silver in a similar quantity in another vessel. Into the vessel containing the silver, throw a spoonful of common salt; stir this up well with a clean piece of wood and let it settle; dissolve some salt in water, and after the silver solution is settled mix a few drops of the salt water in it. If there is any cloudiness formed, it proves that all the silver is not thrown down; more salt must be added, and then stir and allow to settle. If the addition of salt water has no effect, the water may be decanted off, carefully preserving the white deposit. Now pour some boiling water on this deposit; let it settle, and pour off as before. Do this at least three times; pour off as dry as possible, and add about 1 pint clean water, and then by ½ oz. at a time, the cyanide solution, till all the white precipitate is dissolved; add enough water to make ½ gal. Stir well after each addition of cyanide solution. If on dipping the article, which must be well cleaned with brick-dust and water, into this solution the silver deposits immediately and in a dark powder, it must be weakened by adding more water; if it coats slowly, more white precipitate must be prepared, washed, and added to it. This must also be done when the solution is getting short of silver. It works best at about 60°–70° F.; a dry, warm room suits the operation. Brass and copper only can be silvered; other metals require a battery. This method gives a beautiful result when the work is polished and burnished.

(*b*) Clean the articles thoroughly, and then immerse them for a few seconds in a solution of silver cyanide, which will plate them without any further trouble.

(*c*) A silvering solution, which will cover brass, German silver, and copper with a thin but substantial film of silver, may be made by adding to a strong solution of silver nitrate sufficient of a solution of potassium cyanide to redissolve the precipitate at first thrown down. Mix in with this sufficient Spanish whiting or precipitated chalk to make a thin paste. This solution, to obtain its best effect, should be slightly warmed before application, and the articles to be silvered should be clean and free from grease. By scattering or rubbing zinc filings over the surface to be silvered, especially if it be of copper, a much more beautiful effect is produced, the filings being washed off after the silver coating is obtained.

(*d*) To coat copper or brass objects with silver, without difficulty or loss of time, mix 3 parts silver chloride with 20 of powdered cream of tartar and 15 of powdered common salt. Moisten a suitable quantity of the mixture with water, and rub it with a piece of blotting paper upon the metallic object, which must be thoroughly clean. The latter is afterwards rubbed with a piece of cotton upon which precipitated chalk is dusted, then washed with water, and polished with a dry cloth.

Silvering Britannia Metal, Pewter, and all Combinations of Lead and Tin.—These are best placed in a solution containing a good deal of free cyanide, and the deposit should be rapid at first. The surface of the anode should be about three times that required for German silver, and the battery power strong, but not too intense. It is better not to disturb these articles in the solution at the beginning of the deposit. Afterwards they may be shifted for obtaining a uniform coat. If the articles, when they have been a short time in the plating bath, present an unequal surface, remove them, and brush over again as before; then, after well rinsing, return quickly to the bath and allow them, if possible, to remain without further disturbance.

Silvering Clock Dials.—Rub the dial with a mixture of silver chloride, tartar, and sea-salt, and afterwards rub off the saline matter with water. This silvering is not durable, but it may be improved by heating the article, and repeating the operation, once, or oftener if thought necessary.

Silvering Copper Ingots.—The principal difficulties in plating copper ingots are, to bring the surfaces of the copper and silver into fusion at the same time, and to prevent the copper from scaling; for which purposes fluxes are used. The surface of the copper on which the silver is to be fixed must be made flat by filing, and should be left rough. The silver is first annealed, and afterwards pickled in weak spirit of salt; it is planished, and then scraped on the surface to be fitted on the copper. These prepared surfaces are anointed with a solution of borax, or strewed with fine powdered borax itself, and then confined in contact with each other by binding wire. When they are exposed to a sufficient degree of heat, the flux causes the surfaces to fuse at the same time, and when cold they are firmly united. Copper may likewise be plated by heating it, and burnishing leaf silver upon it; so may iron and brass.

Silvering Glass.—(*a*) 10 gr. pure silver nitrate to 1 oz. distilled water; add carefully, drop by drop, strong ammonia, until the brown precipitate is redissolved. When adding the ammonia, keep stirring with a glass rod. In another bottle make a solution of 10 gr. pure crystallised Rochelle salt to 1 oz. distilled water; then, when you have all ready, pour on sufficient to cover all the glass, using two-thirds of the silver solution, and one-third of the Rochelle salt. The mirror can be prepared well by cleaning it with a little wet rouge, and polished dry with a wash-leather; then warm the glass before the fire, or by letting it lie in the sun, to about 70–80° F. Pour on the solution as described above, and let it stand in the warm sunshine ½–1 hour. When silvered, pour on it some clean soft or distilled water, and, while still wet, wipe it very gently all over with a little soft wadding, wet; this will take off all the roughness, so that it will take but little rubbing with the rouge leather to polish it. When perfectly dry, it is easily rubbed up to an exquisite polish.

(*b*) Cheap Looking-glasses.—Place a sheet of glass, previously washed clean with water, on a table, and rub the whole surface with a rubber of cotton, wetted with distilled water, and afterwards with a solution of Rochelle salts in distilled water, 1 of salt to 200 of water. Then take a solution, previously prepared by adding silver nitrate to ammonia of commerce; the silver being gradually added until a brown precipitate commences to be produced; the solution is then filtered. For each square yard of glass take as much of the above solution as contains 20 grm.

(about 309 gr.) silver, and to this add as much of a solution of Rochelle salt as contains 14 grm. salt, and the strength of the latter solution should be so adjusted to that of the silver solution that the total weight of the mixture above mentioned may be 60 grm. In a minute or two after the mixture is made it becomes turbid, and it is then immediately to be poured over the surface of the glass, which has previously been placed on a perfectly horizontal table, but the plate is blocked up at one end, to give it an inclination about 1 in 40; the liquid is then poured on in such a manner as to distribute it over the whole surface without allowing it to escape at the edges. When this is effected, the plate is placed in a horizontal position at a temperature of about 68° F. The silver will begin to appear in about 2 minutes, and in 20–30 minutes sufficient silver will be deposited. The mixture is then poured off the plate, and the silver it contains is afterwards recovered. The surface is then washed four or five times, and the plate is set up to dry. When dry, the plate is varnished, by pouring over it a varnish composed of gum dammar, 20 parts; asphalt or bitumen, 5; gutta-percha, 5; and benzine, 75. This varnish will set hard on the glass, and the plate is then ready for use.

(*c*) Drayton's Process.—A mixture is made of 1 oz. coarsely pulverised silver nitrate, $\frac{1}{2}$ oz. spirits of hartshorn, and 2 oz. water, which, after standing for 24 hours, is filtered, the deposit upon the filter, which is silver, being preserved, and an addition is made thereto of 3 oz. spirits of wine, at 60° above proof, or naphtha; 20–30 drops oil of cassia are then added; and, after remaining for about 6 hours longer, the solution is ready for use. The glass to be silvered with this solution must have a clean and polished surface; it is to be placed in a horizontal position, and a wall of putty or other suitable material is formed around it, so that the solution may cover the surface of the glass to the depth of $\frac{1}{8}$–$\frac{1}{4}$ in. After the solution has been poured on the glass, 6–12 drops of a mixture of oil of cloves and spirits of wine, in the proportion of 1 part, by measure, oil of cloves to 3 of spirits of wine, are dropped into it at different places; or the diluted oil of cloves may be mixed with the solution before it is poured upon the glass; the more oil of cloves used, the more rapid will be the deposition of the silver; but the operation should occupy about two hours. When the required deposit has been obtained, the solution is poured off; and as soon as the silver on the glass is perfectly dry, it is varnished with a composition formed by melting together equal quantities of beeswax and tallow. The solution, after being poured off, is allowed to stand for 3–4 days, in a close vessel, as it still contains silver, and may be again employed after filtration, and the addition of a sufficient quantity of fresh ingredients to supply the place of those which have been used. About 18 gr. silver nitrate are used for each square foot of glass; but the quantity of spirit varies somewhat, as its evaporation depends upon the temperature of the atmosphere, and the duration of the process. By the addition of a small quantity of oil of carraway or thyme, the colour of the silver may be varied. The oil of cassia purchased of different manufacturers varies in quality; therefore on being mixed with the solution it must be filtered previous to use.

(*d*) Large Mirrors for Photography.—Dissolve 150 gr. silver nitrate in 6 oz. distilled water, and to this add ammonia, drop by drop, until the precipitate at first thrown down is redissolved. Now, having made a solution ofcaustic potash, in the proportion of $2\frac{1}{4}$ oz. to 50 oz. water, add 15 oz. of this to the above solution of silver; and add ammonia as before, until the deep-brown precipitate again thrown down is redissolved. Now add 29 oz. distilled water, after which drop in some solution of silver nitrate, gently stirring all the while with a glass rod, until a precipitate begins to be formed. Previous to the immersion of the glass to be silvered, dissolve 1 oz. sugar of milk in 10 oz. water. This must be filtered and kept in a separate bottle. Have ready a clean glass vessel of a size sufficient to contain the glass plate to be silvered; when everything is ready, mix together the silver solution with that of the sugar of milk, in the proportion of 10 of the former to 1 of the latter. Lower the glass down in the solution until it is a little distance from the bottom, and allow it to remain there for a period varying from 15 minutes to 4 hours, according to the thickness of the coating of silver desired. After removing it from the bath, wash with distilled water, and, when dry, polish by means of a soft pad of cotton-velvet charged with rouge. An intensely brilliant surface may be thus obtained on both sides of the glass plate. Make a 3-gr. solution of ammonio-nitrate of silver. Render it slightly turbid by excess of silver nitrate, and then filter it. Just before using it, add to each ounce of the foregoing solution 2½ gr. Rochelle salt, immerse the glass as before, and expose to a subdued light while it remains in the bath. In about 2 hours the deposit of silver will be sufficiently thick.

(*e*) Specula.—Prepare three standard solutions. Solution A—Crystals of silver nitrate, 90 gr.; distilled water, 4 oz.; dissolve. Solution B—Potassa, pure by alcohol, 1 oz.; distilled water, 25 oz.; dissolve. Solution C—Milk-sugar, in powder, ½ oz.; distilled water, 5 oz. Solutions A and B will keep in stoppered bottles for any length of time; solution C must be fresh.

To prepare sufficient for silvering an 8-in. speculum, pour 2 oz. solution A into a glass vessel capable of holding 35 oz. Add, drop by drop, stirring all the time with a glass rod, as much liquid ammonia as is just necessary to obtain a clear solution of the grey precipitate first thrown down. Add 4 oz. solution B. The brown-black precipitate formed must be just redissolved by the addition of more ammonia, as before. Add distilled water, until the bulk reaches 15 oz., and add, drop by drop, some of solution A, until a grey precipitate, which does not redissolve after stirring for three minutes, is obtained; then add 15 oz. more distilled water. Set this solution aside to settle. Do not filter. When all is ready for immersing the mirror, add to the silvering solution 2 oz. solution C, and stir gently and thoroughly. Solution C may be filtered.

Procure a circular block of wood, 2 in. thick, and 2 in. less in diameter than the speculum. Into this should be screwed three eye-pins, at equal distances. To these pins fasten stout whipcord, making a secure loop at the top. Melt some pitch in any convenient vessel, and, having placed the wooden block, face upwards, on a level table, pour on it the fluid pitch, and on the pitch place the back of the speculum, having previously moistened it with a little spirits of turpentine, to secure adhesion. Let the whole rest until the pitch is cold.

Place the speculum, cemented to the circular block, face upwards, on a level table; pour on it a small quantity of strong nitric acid, and rub it gently all over the surface with a brush made by plugging a glass tube with pure cotton-wool. Having perfectly cleaned the surface and sides, wash well with common water, and finally with distilled water. Place the speculum, face downwards, in a dish containing a little rectified spirits of wine, until the silvering fluid is ready.

(*f*) On the whole, the Rochelle salt process is the most certain, as well as the simplest. The two solutions are made thus:—Solution A—Silver nitrate in crystals, 10 gr.; distilled water, 1 oz. Dissolve the crystals in the water, then add liquid ammonia, drop by drop, until the grey precipitate is just redissolved. A few drops more of the silver solution are added, until there is a slight permanent precipitate, which does not redissolve. This solution is now filtered, and, if not required for immediate use, will keep for years. Perfect films have been produced with solution made nearly twenty years before. Solution B—Rochelle salt (potassio-tartrate of soda) dissolved in distilled water. In the original formula it was specified that crystals must be used, and the strength was 10 gr. to the oz.; but crystals of Rochelle salt are not easy to get, and I used to dissolve some of the ordinary powdered variety in water and recrystallise it; but I am now using 25 gr. of the powder instead, with perfect success and much less trouble. This solution does not keep more than a few days. The glass to be silvered is cleaned in the usual way with pure nitric acid—some of the acid being poured on its surface and well spread with a brush or mop made by tying some calico round the end of a rod or strip of glass, using plenty of acid, and washing it off with a good stream of water from a tap; finishing with distilled water, and laying the glass, face downwards, in a dish of distilled water until everything else is ready. The dish in which the glass is to be silvered should be thoroughly cleaned and rinsed with distilled water, and should allow the mirror to lie face downwards with a depth of at least ¼ in. between it and the bottom of the dish. The mirror may be supported on two small blocks of glass cemented by shellac to the bottom of the dish at the extremities of diameter, or the mirror may have a block of wood fixed on its back by pitch, and be suspended by strings. This should be done before cleaning, and the necessary quantity of bath solution ascertained. When all is ready, equal parts of silver ammonio-nitrate (solution A), of Rochelle salt (solution B), and of distilled water are taken and mixed together, and the cleaned mirror is immersed in it. In a few minutes the solution will turn brown, then nearly black, and a silver film will be seen to form on the glass surface, and gradually spread over it. This takes place more rapidly if the solutions and mirror are all warmed to about 90° F., when the process will be completed in a few minutes; but, with cold solutions, and leaving all at rest all night, you may get good, dense, brilliant films. When the silvering is completed, the glass is well washed with plenty of water, finishing with distilled water, and set on edge to dry, after which it is gently polished with wash-leather, and a little very fine rouge.—(A. W. Blacklock.)

(*g*) Some additional hints which experience has shown to be necessary for complete success are as follows:—

One of the most essential preliminaries is to see that the mirror to be silvered is chemically clean. When pitching on the block for suspension in the silver fluid, in spite of every care, the front surface of the mirror is very liable to be stained by pitch on the fingers, or particles touching the glass, and no amount of washing by water, or even nitric acid, will thoroughly remove the stains. The mirror will be spotted and speckled, when silvered, and the failure disheartening. To avoid this, first sponge the surface to be silvered, and the edges of the mirror, with turpentine, then wash well with soap and water under a flowing tap, and, finally, sponge the surface with a solution of nitric acid, washing afterwards with pure water till every trace of acid is removed. The mirror will then be chemically clean.

Another fruitful source of failure arises from water dripping from the back and sides of the mirror into the silvering solution. To prevent this, when the mirror is chemically cleaned, place it at once, face downwards, into a dish of distilled water, which contains just so much as will completely cover the surface of the mirror, and come up one-third of its depth. Here leave it till the silvering solution is mixed, and everything is ready for immersion.

By this time the back of the mirror is dry, and so much of the edge as will, when the mirror is immersed, be above the solution. Thus the dripping will be avoided, and the mirror will take the silvering, pure and clean, all round the edges, as well as in the central zones.

Transfer the mirror from the distilled water as quickly as possible, taking care that it sinks to the proper depth in the silvering solution, and equally all round.

With respect to the strength of the solution in winter, it is better to make it (as far as silver is concerned) a little stronger than that given in the formula, and also, in cold weather, it will often take a much longer time than an hour to produce a satisfactory result. If taken out too soon, in cold weather, the coating will be so thin that it cannot be polished.

Have a large jug of water ready at hand, and wash immediately on removal from the solution; then under a tap for ¼ hour. If the process has been, as it ought to be, successful, the mirror may be polished, after 3–4 hours' drying in a warm room; but it is better to defer the polishing till the next day to secure perfect dryness and firmness.—(S. Mills.)

(*h*) Prof. Palmieri has devised a process for silvering glass by means of a reducing action on the salts of silver, which is said to have the advantage of producing a very brilliant metallic deposit. When into an ammoniacal solution of silver nitrate is poured, first a little caustic potash, and then a few drops of glycerine, the reduction begins at once; and this action is accelerated if ether or alcohol be added to the mixture. A moderate heat and darkness are said to increase the brilliancy of the precipitate, and darkness also favours the adhesion of the deposit to the mirror.

(*i*) Solution 1. Silver nitrate, 1 oz.; water, 10 oz. Solution 2. Caustic potash, 1 oz.; water, 10 oz. Solution 3. Glucose, ½ oz.; water, 10 oz.

The above quantities are those estimated for 250 sq. in. of surface. Add ammonia to solution No. 1 till the turbidity first produced is just cleared. Now add No. 2 solution, and again ammonia to clear; then a little solution, drop by drop, till the appearance is decidedly turbid again. Then add No. 3 solution, and apply to the clean glass surface. A film was obtained in 43 minutes at a temperature of 56° F. The plate of glass was rather large: 37 in. diameter and 4½ in. thick, and weighed 4 cwt.—(A. A. Common.)

(*k*) Prepare four solutions—first, 10 grm. silver nitrate to 100 grm. water; second, an aqueous solution of ammonia of 0·984 density; third, 20 grm. caustic soda and 500 grm. water; and fourth, a solution of 25 grm. sugar in 200 grm. water, to which is added 1 cc. nitric acid at 36° B.; and let the whole boil for 20 minutes. When cold add 50 cc. alcohol, and as much water as will make up the total quantity to 500 cc.; then take 12 parts of the first, 8 parts of the second, and 20 parts of the third solution, and 60 parts of water, and let the mixture stand for 24 hours; lastly, the solution No. 4 is added when the whole becomes of a blackish tint, in consequence of the finely-divided precipitate of silver which begins to fall.

(*l*) To microscopists, who, like the writer, live remote from the great commercial and industrial centres, and who are consequently frequently compelled to rely on their own mechanical skill and ingenuity, or their own technical knowledge, in emergencies where their more fortunate brethren can call to their aid the services of skilled mechanicians and instrument makers, the following will prove interesting and valuable. A short time since, minute specks began to show themselves in the mirrors, both plane and concave, of my Nachet microscope, and soon both became worthless as reflectors. Upon examination I found that the varnish protecting the amalgam had cracked into numberless little fissures, and the amalagam itself had become detached from the glass. Compelled to use my instrument almost every day, professionally, whilst it would require from two to three weeks to send off to have the damage repaired, I determined to resilver the mirrors by one of the processes now in general use in the arts and sciences, and of which to a certain extent, I had my choice.

While a student, several years ago in the laboratory of Baron von Liebig, in Munich, I assisted in conducting a series of experiments looking to the manufacture of silvered mirrors on a large commercial scale (with a view of doing away with the mercurial amalgam process, which pernicious industry was then attracting general attention in Bavaria), and by the use of the Liebig method, and what was afterwards known as the

Siemens modification of the same had succeeded in making some exquisite mirrors of a large size and almost perfect reflecting surface. Where ammonium aldehyde (C_2 H_3 (NH_4) O) can be obtained, there is no doubt that this is the best and most economical process, whether used on a large or a small scale.

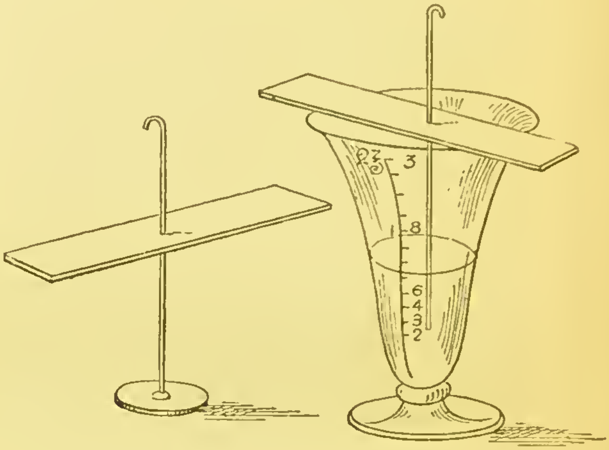
The next best process is based upon the reduction of metallic silver from its ammoniacal solution by salts of tartar. Having tried several formulæ of this kind, all of them more or less simple, as well as efficacious, I have found the following to yield the best results in the shortest time.

Silvering Solution.—In 1 oz. distilled or pure rain water, dissolve 48 gr. crystallised silver nitrate. Precipitate by adding strongest water of ammonia, and continue to add the ammonia drop by drop, stirring the solution with a glass rod, until the brown precipitate is nearly, but not quite, redissolved. Filter, and add distilled water to make 12 fl. dr.

Reducing Solution.—Dissolve in 1 oz. distilled or very clean rain water, 12 gr. potassium and sodium tartrate (Rochelle or Seignette salts). Boil in a flask, and while boiling add 2 gr. crystallised silver nitrate dissolved in 1 dr. water. Continue the boiling 5–6 minutes. Let cool, filter, and add distilled water to make 12 fl. dr.

To Silver.—For a mirror 1¼–1½ in. diameter, take an ordinary 2 oz. graduated glass; procure a piece of thin wood (cigar box will do) long enough to go across the top of it, and through the centre of the wood thrust, as shown in Fig. 103, a wire 7–8 in. long. After cleansing the glass to be silvered by immersing it in strong nitric acid, washing in liquor potassæ, and thoroughly rinsing with distilled water, with a bit of sealing wax attach one end of the wire to its face, as in Fig. 103. If the glass has had mercurial amalgam on it, it will probably be necessary to clean the back with rouge. On having this surface perfectly, chemically clean, depends in a great measure the success of the operation.

Fig. 103.



Having attached the glass to the wire, lay the strip across the graduate, move the glass disc downwards until it nearly, but not quite, touches the sides of the graduate all round, taking care that its edges shall be as nearly level as possible. Having ascertained the height in the graduate at which the disc should stand, bend or clamp the wire so that it cannot slip. In the ordinary American graduate, with a mirror 1⅜ in. diameter, this will be at the 6 dr. mark, as nearly as may be. Remove the glass and pour into the graduate enough of equal quantities of the two solutions to fill the graduate exactly to the previously ascertained level. Stir the solutions so that they will become thoroughly mixed, and replace the disc to be silvered, taking great care that the surface to be silvered shall come in contact with the silvering fluid exactly at all points. The disc should be rinsed carefully before replacing, and should be put in while wet. Great care should be taken that no air bubbles remain on the surface of the solution, or between it and the surface to be silvered.

Now set the graduate in the sun for a few minutes, if the weather be warm, or by the fire, if it be cold, as a temperature of 113°–122° F. is most conducive to the rapid deposition of a brilliant, firm, and even film of silver. The fluid in the sunlight soon becomes inky black, gradually clearing as the silver is reduced, until when exhausted it is perfectly clear. The mirror should be removed before this point is reached, as a process of bleaching sets up if left after the fluid is exhausted. From 20–80 minutes, according to the weather, purity of chemicals, &c., is required for the entire process.

When the mirror is removed from the bath, it should be carefully rinsed with distilled water from the wash bottle, and laid on its edge on blotting paper to dry. When perfectly dry, the back should be varnished with some elastic varnish and allowed to dry. The wire and sealing-wax can now be removed from the face, and the glass cleaned with a little pledget of cotton and a minute drop of nitric acid, taking great care that the acid does not get to the edges or under the varnish. Rinse, dry, and the mirror is finished.

The light reflected from a mirror made thus has somewhat of a yellowish tinge, but photometric experiments show that 25–30 per cent. more light is reflected than from the old mercurial mirrors.—(Dr. James.)

(*m*) In Brashear's process the most important thing is the sugar solution forming the reducing agent. This greatly improves by keeping—a solution that has been made some months being much more effective than a newly-made one. It is convenient to have always some Winchester quarts of it in stock for use. I have, for convenience, varied his proportions slightly, and thus give them, as I have found them work so well. For the sugar solution I add to 10 per cent. of loaf sugar, in distilled water, 10 per cent. alcohol and ½ per cent. nitric acid. Solutions of 10 per cent. silver nitrate and of caustic potash are separately prepared, the latter one as wanted. These, with sufficient ammonia and a very dilute solution of silver nitrate, and also a similar very dilute one of ammonia, are prepared, the latter in order to obtain that pale brown colour of the ammoniated solution of silver nitrate that is absolutely necessary to have before adding the reducing agent.

Having selected a suitable dish to contain the liquid, in which the mirror can be placed face downwards with about ½–¾ in. of liquid underneath, find on the basis of 1 of silver-nitrate solution to 4 of the total required liquid the amount of silver solution needed; to this add ammonia till the first formed precipitate is dissolved, then add one half of this quantity of the potash solution (this is a variation from Mr. Brashear's formula that I have found works well), and again add ammonia till the mixed solution is quite clear, taking care to put in only sufficient ammonia for that purpose; then add the weak solution of silver nitrate till a clear brown colour is obtained; should this become a dark brown, some of the weak solution of ammonia will bring it to a pale brown colour, which must persist if the solution is left standing some time.

The mirror, previously cleaned with nitric acid and distilled water, and suspended in the dish in distilled water of sufficient amount to make up on addition of the solutions the total liquid required, is lifted out, and the prepared solutions are mixed with the distilled water and an amount of the reducing solution equal to about one half that of the silver nitrate solution, more or less, as the temperature is under or over 60° F.; as soon as all is intimately mixed, the mirror is immersed with one movement, beginning by dipping the edge first and lowering so as to prevent any air-bubbles forming under the glass. In 3–5 minutes the silver begins to form on the mirror, the solution changing from pink to dark brown and black, the film thickens quickly, and in 25–30 minutes sufficient silver is deposited. The mirror can then be washed and put to soak in distilled water for a few hours, then taken out and dried and polished in the usual way, that is, with a soft pad of clean chamois, and going all over the mirror with light strokes till the bloom is all removed and a fair polish is obtained, finishing with a very little of the finest washed rouge, quite dry, lightly dusted on the pad; it is very important to well consolidate the film of silver by the unrouged pad before using any polishing powder.

It is a very good plan for any one who is not in the habit of silvering, or to whom the process is strange, to try the proportions of the solutions on some small pieces of glass till a satisfactory proportion for the temperature (for that is the chief factor in varying the amount of reducing solution necessary) of the room in which he is working. The most important thing (after the solutions) is the proper cleansing of the glass, for on the proper preparation of the surface of the glass a very great deal depends.

As already stated, this process is used when the glass to be silvered can be suspended in the liquid: it is not suitable when we attempt to silver surfaces face upwards. The mud formed settles down and prevents any proper deposition of silver; this was a source of considerable trouble when it was required to silver the 3-ft. mirror, and a pneumatic arrangement was eventually made to hold the mirror by the back, so that it could be silvered face downwards, and up to that size the silvering could be managed.

The great size of the 5-ft. mirror and its enormous weight (over half a ton without the cell) made it dangerous to suspend it, and the question of silvering became a serious one. In making experiments, in order to get rid of the mud formed in the process last mentioned, it was found that by leaving out the potash the silver was deposited from a nearly clear liquid and no mud was formed, and the first 5-ft. mirror was very successfully silvered in this manner. The solutions of silver and sugar are used in the same proportions without potash, but it is found advisable to use a stronger total mixture. For subsequent silvering of the 5-ft. mirror the Rochelle salt process has been used, and this for the deposition of the silver on a surface face up seems to be the best, using if necessary two or more applications.

In preparing a large mirror for silvering in this manner it is necessary to form it into a dish by using a band of paraffined brown paper round the edge, standing up an inch or more all round, and mounting the mirror on a swinging support, so that it can be tipped up to throw off the water or spent solutions; in the case of the 5-ft. mirror, when mounted on this machine this tipping up could be done by the same arrangement used for placing the mirror vertical for testing.

The proportions of solutions used for the 5-ft. were for each application 3000 cc. silver solution ammoniated as already described, and 500 cc. Rochelle salt solution, with about 29,000 cc. distilled water; this remained on the mirror 28 minutes; another similar application was left on for 30 minutes; after thorough washing, distilled water was left on for some hours, and the film was dried and polished.

A very fine film of silver was deposited on a 5-ft. mirror, using one application only of 4000 cc. silver solution and 750 cc. Rochelle salt solution—this after one year was found to be in a very good state indeed; this was on the first mirror which, from some defect in the glass could not be made into a good mirror. The disc of glass was returned to the makers to be replaced by another. I took this opportunity of removing and collecting the whole of the silver by dissolving it in nitric acid. The assay of the deposit gives a total weight of 26·5 gr. silver on a surface of 2800 sq. in.; in actual weight somewhere between that of a threepenny and fourpenny piece, not a large amount of the 400 grm. of the silver nitrate used in depositing the film. The actual waste need not be very much, as the silver chloride can be easily deposited by the addition of common salt to the spent solutions, and the silver thus recovered.

It will be seen that the various processes all have the ammoniated solution of silver nitrate, and differ only in the reducing agent. The preparation of this solution, in order to get the pale brown colour already spoken of, demands some care. If the solution is too strong, on the addition of ammonia a very flocculent deposit is formed, difficult of re-solution. If after the solution is cleared by the addition of ammonia a strong solution of silver nitrate is added to get this colour, this flocculent deposit occurs; but if the weak solution advised be used, there is no difficulty in getting the proper colour free from any deposit. This is important. A word of caution may not be out of place concerning the production sometimes of a fulminate of silver, recognised by its dark grey metallic lustre. This is extremely liable to explode with great violence on the contact of almost anything; a few drops of water once sufficed to explode some in a beaker and blew it to fragments. By using moderately dilute solutions this danger is obviated. My own experience is not singular in this respect, for Mr. Brashear relates a similar occurrence.

The silver film is not always of the same quality, and experiments are needed to get more information as to what determines the greater density and coherence of some films over others. I have had surfaces of glass silvered experimentally where the film would not wash off with any amount of wet rubbing, these mostly on surfaces that had been silvered many times. Probably the glass in this case was in the best state to receive the new deposit; certainly the condition of the surface does affect the coherence of the silver as well as the amount of the deposit, as judged by the way in which certain parts on a mirror that has been incompletely cleaned show that the deposition has begun long before other parts, necessarily resulting in an unequal thickness of film. With the most careful cleaning of a mirror I have often found that the first application did not succeed, but the second on the surface just cleaned off with nitric acid was all right. The nature of the liquid other than distilled water last in contact with the surface of the mirror seems to be the determining thing.—(Common.)

(*n*) Partially Resilvering Pier Glass.—Remove the silvering from the injured part, clean the glass, form a wall of beeswax round the spot, pour on it some silver nitrate, and precipitate the silver by sugar, or oil of cloves and spirits of wine. This does not leave a white mark round the prepared place.

(*o*) Curved Glass.—This is a French process, used not only for flat surfaces, but also for those which are curved, or cut into patterns. Dissolve 600 gr. neutral silver nitrate in 1200 gr. distilled water, add 75 drops of a solution composed of 25 parts distilled water, 10 ammonia sesquicarbonate, and 10 ammonia, sp. gr. 0·980; add also 30 gr. ammonia, same sp. gr., and 1800 gr. alcohol, sp. gr. 0 85. When clear, the liquor is decanted or filtered, and mixture of equal parts alcohol and oil of cassia is added to the silver solution in the proportion of 1 of the oil of cassia to 15 of the silver solution; the mixture is agitated and left to settle, then filtered. Before pouring upon the glass surface, or into the glass vessel to be silvered, the solution is mixed with 1–78th its bulk of essence of cloves, 1 part oil of cloves, 3 parts alcohol. The glass is thoroughly cleaned, and the silver solution is applied and warmed to 100° F. for about 3 hours; the liquid is poured off, and the silver deposit is washed, dried, and varnished.

(*p*) Watch Glass.—Take a solution of silver nitrate in a watch glass (1 gr. of the salt to 30 cc. water), add very dilute ammonia, drop by drop, until the precipitate formed is partially dissolved. Add a drop of a solution of sodium and hydrogen tartrate. The liquid will turn black and the silver will be deposited on the watch glass, forming a brilliant mirror-like coating. The watch glass should be imbedded in some sand, and the sand gently warmed.

(*r*) Glass Globes.—Take $\frac{1}{3}$ oz. clean lead, and melt it with an equal weight of pure tin; then immediately add $\frac{1}{2}$ oz. bismuth, and carefully skim off the dross; remove the alloy from the fire, and before it grows cold add 5 oz. mercury, and stir the whole well together; then put the fluid amalgam into a clean glass, and it is fit for use. When this amalgam is used for silvering, let it be first strained through a linen rag; then gently pour some ounces thereof into the globe intended to be silvered; the alloy should be poured into the globe by means of a paper or glass funnel reaching almost to the bottom of the globe, to prevent it splashing the sides; the globe should be turned every way very slowly, to fasten the silvering.

(*s*) Make an alloy of 3 oz. lead, 2 oz. tin, and 5 oz. bismuth; put a portion of this alloy into the globe, and expose it to a gentle heat until the compound is melted; it melts at 197° F.; then by turning the globe slowly round an equal coating may be laid on, which, when cold, hardens and firmly adheres. This is one of the cheapest and most durable methods of silvering glass globes internally.

(*t*) Silver nitrate, 1 oz.; distilled water, 1 pint; strong liquor ammonia, sufficient quantity, added very gradually, to first precipitate and then redissolve the silver; then add honey, ¼ oz. Put sufficient quantity of this solution in the globe, and then place the globe in a saucepan of water; boil it for 10–30 minutes, occasionally removing it to see the effect.

Silvering Iron.—(*a*) 15 grm. silver nitrate are dissolved in 250 grm. water, and 30 grm. potassium cyanide are added; when the solution is complete, the liquid is poured into 750 grm. water, in which 15 grm. common salt have been previously dissolved. The cast iron intended to be silvered by this solution should, after having been well cleaned, be placed for a few minutes in a bath of nitric acid of 1·2 sp. gr., just previous to being placed in the silvering fluid.

(*b*) Polish the surface very clean and level with a burnisher; then expose it to a blueing heat; a leaf of silver is to be properly placed and carefully burnished down. This is repeated until sufficient leaves are applied to give the silver a proper body.

(*c*) By solder. Slips of thin solder are placed between the iron and silver, with a little flux, and secured together by binding wire. Then place in a clear fire until the solder melts; when it is taken out, on cooling, it will adhere firmly.

(*d*) By tinning the iron first, and uniting the silver by means of slips of rolled tin, brought into fusion in a gentle heat.

(*e*) A manufacturer in Vienna employs the following process for silvering iron. He first covers the iron with mercury, and silvers by the galvanic process. By heating to 570° F., the mercury evaporates and the silver layer is fixed. Ironware is first heated with dilute hydrochloric acid, and then dipped in a solution of mercury nitrate, being at the same time in communication with the zinc pole of an electric battery, a piece of gas carbon or platinum being used as an anode for the other pole. The metal is soon covered with a layer of quicksilver, and is then taken out and well washed and silvered in a silver solution. To save silver, the ware can be first covered with a layer of tin; 1 part cream of tartar is dissolved in 8 of boiling water, and one or more tin anodes are joined with the carbon pole of a Bunsen element. The zinc pole communicates with a well-cleaned piece of copper, and the battery is made to act till enough tin is deposited on the copper, when this is taken out and the ironware is put into its place. The ware thus covered with tin chemically pure and silvered, is much cheaper than any other silvered metals.

(*f*) De Villiers has invented a metallic alloy for silvering. It consists of 80 parts tin, 18 of lead, and 2 of silver, or 90 of tin, 9 of lead, and 1 of silver.

The tin is melted first, and when the bath is of a brilliant white the lead is added in grains, and the mixture is stirred with a stick of pine wood, the partially melted silver is added, and the mixture is stirred again. The fire is then increased for a little while, until the surface of the bath assumes a light yellow colour, when it is thoroughly stirred up and the alloy is cast in bars.

Whenever there is a choice between iron and steel, in making any article, the best quality of steel is to be preferred. The operation is then carried out in the following manner:—

The article, a knife blade for example, is dipped in a solution of hydrochloric or sulphuric acid (1–10 parts acid in 100 of water). After taking it out of this pickle, it is immediately rinsed with clean water, then dried and rubbed with a piece of soft leather or dry sponge, and finally exposed to a heat of 158°–176° F., for 5 minutes in a muffle. The object of this is to prepare the iron or steel to receive the alloy, by making the surface porous or covered with small microscopic holes. If the iron is not very good these holes are much larger, and frequently flaws and bad places are disclosed, which make the silvering more difficult. With steel the process goes on very regularly.

The article is warmed to 122°–140° F., and dipped in the bath of the above described alloy, which is melted by a gentle fire of graphite or refractory clay. The bath must be perfectly fluid, and is stirred with a stick of pine or poplar; the surface of the bath must have a fine white silver colour. Under these circumstances the object thus prepared quickly takes up the alloy, which penetrates the porous surface. For a knife blade an immersion of 1–2 minutes is sufficient to cover it; larger articles require 5 minutes' immersion. After taking it out of the bath, it is dipped in cold water, or treated in such a way as to temper it, if tempering is necessary. If it is left too long in cold water, it frequently becomes brittle, but this evil can be avoided by a little experience. It is then only necessary to rub it off dry and polish without heating it.

Articles treated in this manner look like silver, and ring like it too, and withstand the oxidising action of the air. To protect them from the effect of acid liquids like vinegar, they are dipped in a bath of amalgam, composed of 60 parts mercury, 39 of tin, and 1 of silver. It is then dipped warm into melted silver, or electro-plated with silver to give it the silvery look. The method of polishing will depend on the shape of the object. This kind of silvering is said to be very durable, and even resist gentle filing. The cost of the process is comparatively small.

Plated Silver Reflectors.—A bath made of water, 1¾ pint; silver nitrate, 2 oz.; potassium cyanide, 10½ oz. Add sufficient Spanish white, or levigated chalk, in fine powder, to produce a thin paste, which is kept in a well-closed pot. This paste is spread by a brush or a pad of old linen, all over the surface of the reflector, and allowed almost to dry, when it is briskly rubbed over by another clean dry rag of old linen.

Silvering on Solder.—The difficulty of obtaining regular deposits of silver over articles which have parts soldered may be greatly obviated by scratch-brushing those parts dry, that is, without the usual liquid employed. This renders these refractory parts better conducting, provided that during the operation no impurities are left on these spots.

Silvering Thermometer Scales.—Take ½ oz. silver nitrate; dissolve in half a tea-cupful of cold water; add ½ lb. cream of tartar, with 1½ lb. common salt, beaten or ground fine. Mix and stir well together, adding water until it attains the consistence of a thick paste. Now lay the scale on a board, the brass or copper being previously well cleaned and cast off from fine sand-paper; rub the silvering on with your hand until it attains the appearance of silver, which will be a minute or so; now take the work off the board and rub a little wet whiting over it, wash out in clean cold water, and dry in saw-dust. If varnished with a thin coat of white hard varnish, reduced in spirits of wine, this will last for years. The above quantity of silvering used with care will silver six dozen brewers' thermometers, 14 in. long.

Desilvering.—(*a*) The following liquid will dissolve silver without attacking copper, brass, or German silver, so as to remove the silver from silvered objects, plated ware, &c. It is a mixture of 1 part nitric acid with 6 parts sulphuric, heated in a water-bath to 160° F., at which temperature it operates best.

(*b*) Mix sulphuric acid, 1 part; nitric acid, 1; water, 1; boil the metal in the mixture till it is dissolved, and throw in a little salt to cause the silver to subside.

(*c*) Nearly fill a flat pan of enamelled cast iron with concentrated sulphuric acid, and heat to a temperature of 300°–400° F.; at the moment of using it, pinches of dry powdered saltpetre are thrown into it; then hold the article with copper tongs in the liquid. The silver rapidly dissolves, and the copper or its alloys are not sensibly corroded. According to the rapidity of the solution, more or fewer pinches of saltpetre are added. All the silver has been dissolved when, after rinsing in water and dipping the articles into the cleansing acids, they present no brown or black spots, that is, when they appear like new metals.

(*d*) For removing the silver from wrought and castiron, zinc, or lead, it is preferable to invert the electric current in a cyanide bath, or to use mechanical processes. Old desilvering liquors become green after use; to recover the silver they are diluted with 4 or 5 times their volume of water, then add hydrochloric acid or common salt. The precipitation is complete when the settled liquor does not become turbid by a new addition of common salt or hydrochloric acid. The resulting silver chloride is separated from the liquid either by decantation or filtration, and is afterwards reduced to the metallic state.

(*e*) For dissolving silver in the cold the objects are hung in a large vessel filled with the following mixture:—Sulphuric acid at 66° B., 10 parts; nitric acid at 40° B., 1, in which they remain for a greater or less length of time, according to the thickness of the coat of silver to be dissolved. This liquid, when it does not contain water, dissolves the silver without sensibly corroding copper and its alloys; therefore avoid introducing wet articles into it, and keep the liquid perfectly covered when not in use. As far as practicable, place the articles in the liquid so as not to touch each other, and in a vertical position, so that the silver salt will fall to the bottom. In proportion as the action of the liquor diminishes, pour in small and gradual additions of nitric acid. Dissolving silver in the cold is regular and certain, but slow, especially when the proportion of silver is great.

Tin Deposits.—*Tinning by Double Affinity.*—The bath is composed of (*a*) Distilled water, 66 gal.; cream tartar, 6½ lb.; tin protochloride, 10½ oz. The powdered cream of tartar is dissolved in 44 gal. warm water, and the tin salt in 22 gal. cold water. The two solutions when mixed become clear, and the resulting bath has an acid reaction.

(*b*) Distilled water, 66 gal.; pyrophosphate of potash or soda, 13 lb.; protochloride of tin, crystallised, acid, 21 oz.; or the same fused, neutral, 14 oz. The whole is dissolved at the same time on a metal sieve, and, after stirring, the bath is clear.

Either of these solutions is kept in a barrel with the top off. This barrel has at its lower part two tubes placed one above the other, connected with a small boiler built below the level of the bottom of the tank. The tube, starting from the bottom of the tank, reaches nearly to the bottom of the boiler; the other tube, which is placed about 3 in. from the bottom of the tank, is connected to the top of the boiler; a bent safety tube, connected only to the boiler, prevents any explosion, should there be an obstruction in the other tubes. A small quantity of water or mercury in the bent arm of the safety tube will prevent the escape of steam, when it does not exceed the working pressure required. When the boiler and tank are filled with liquid, as soon as heat is applied, the expanded and lighter liquid will rise through the upper pipe into the barrel, while the colder and denser one will flow into the boiler through the lower pipe. A continual circulation is thus obtained, which keeps up a constant agitation of the contents of the bath. Large pieces are cleansed and rinsed, and piled in the bath with a few fragments or spirals of zinc; the surface of the zinc should be about $\frac{1}{30}$ of that of the tinned articles. For small objects, such as pins or hooks, dispose them in layers about 1 in. thick upon perforated plates of zinc, which allow of the circulation of the liquid, and have their edges turned up so as to prevent the objects from falling off. These plates should be removed from the bath in the inverse order in which they have been put in. These zinc plates must be scraped and cleaned, so as to present fresh surfaces of zinc instead of the white crust, which prevents its contact with the articles to be tinned. The time for the operation varies from 1 to 3 hours. Then remove all the objects, and add to the bath 9 oz. pyrophosphate, and as much fused tin protochloride. Whilst the solution is going on, scratch-brush the large articles, and stir the small ones about with an iron fork, to change the points of contact. The objects are then again steeped in the bath for at least 2 hours. The large pieces are scratch-brushed again, and the small ones rendered bright by mutual friction. Then dry the whole in dry and warm fir-wood saw-dust. Cast-iron cooking vessels thus tinned have a bright appearance, and have the advantage of never communicating any taste, smell, or colour to the food cooked in them, even when the tinning, after long use, has completely disappeared.

Cold Tinning.—Block tin dissolved in muriatic acid with a little mercury forms a very good amalgam for cold tinning; or, 1 part of tin, 2 of zinc, 6 of mercury. Mix tin and mercury together until they form a soft paste. Clean the metal to be tinned, taking care to free it from greasiness; then rub it with a piece of cloth moistened with muriatic acid, and immediately apply a little of the amalgam to the surface, rubbing it in with the same rag. The amalgam will adhere to the surface and thoroughly tin it. Cast iron, wrought iron, steel, and copper may be tinned this way. Those who find it difficult to make soft solder adhere to iron with sal ammoniac, will find no difficulty if they first tin the surfaces in this manner, and then proceed as with ordinary tin plate.

Electro-Tinning.—The bath is composed of rain or distilled water, 110 gal.; pyrophosphate of soda or potash, 11 lb.; crystallised protochloride of tin, 21 oz.; or 18 oz. of the same salt fused, in order to have it free from an excess of acid; put the water into a tank entirely lined with anodes of tin sheets, united together and connected with the positive pole, carbon or copper, of the battery. Then introduce the pyrophosphate, and stir it in; when dissolved, the tin protochloride is put into a sieve of copper half immersed in the solution. A milky-white precipitate is produced, which disappears after continued agitation. When the liquid has become clear and colourless, or only slightly yellow, the bath is ready; then place upon transverse metallic rods, connected with the negative pole, the previously cleansed objects which are to be tinned. The anodes are not sufficient to keep the bath saturated; when the deposit is too slow add small portions of equal weights of tin salt and pyrophosphate; put in by the aid of the sieve, as if fragments of protochloride fall to the bottom of the bath they become covered with a crust, which prevents their solution. The tinning thus obtained upon any kind of metal is quite resisting, and has a white and dead lustre resembling that of silver. A bright lustre may be obtained with the scratch-brush or the burnishing tool. The reduction of these baths requires an intense current, and the working of the batteries is expensive.

Tinning Small Articles.—Place them in warm water, with a little sulphuric acid added to it, which will clean them; then powder some sal ammoniac and mix it in the water, stirring well until all is dissolved. After washing the articles in clean water, place them in the solution for a few minutes; then lay them by the fire to dry. Procure a pan resembling a frying-pan in shape, the bottom of which must be full of small holes. The pot for melting the tin must be large enough to admit the pan for holding the articles. Cover the bottom of the pan with the articles to be tinned, and, after sprinkling a little powdered sal ammoniac over the surface of the molten tin to clear it from dross, dip the pan containing the goods into it; after all smoke has disappeared, lift it out and shake well over the pot, sprinkling a little sal ammoniac over the goods to prevent them from having too thick a coat, then cool quickly in cold water to keep them bright.

Whitening by Tin.—This is effected by boiling for 2–3 hours in long copper troughs, crude cream of tartar with tin plates supporting a layer of about ½ in. of the small articles to be whitened. The whole charge is composed of alternate layers of articles and tin plates, so that each layer of articles is between two tin plates. This process will not succeed with iron without an intermediate coat of copper has been deposited.

Crystallised Tin-Plate is a variegated primrose appearance, produced upon the surface of tin-plate, by applying to it in a heated state some dilute nitro-muriatic acid for a few seconds, then washing it with water, drying, and coating it with lacquer. The figures are more or less diversified, according to the degree of heat, and relative dilution of the acid. Place the tin-plate, slightly heated, over a tub of water, and rub its surface with a sponge dipped in a liquor composed of 4 parts aquafortis, and 2 distilled water, holding 1 of common salt or sal ammoniac in solution. When the crystalline spangles seem to be thoroughly brought out, the plate must be immersed in water, washed either with a feather or a little cotton, taking care not to rub off the film of tin that forms the feathering, forthwith dried with a low heat, and coated with a lacquer varnish, otherwise it loses its lustre in the air. If the whole surface is not plunged at once in cold water, but is partially cooled by sprinkling water on it, the crystallisation will be finely variegated with large and small figures. Similar results will be obtained by blowing cold air through a pipe on the tinned surface, while it is just passing from the fused to the solid state.

Colour of Tin Deposit.—If the tin deposit is grey and dull, although abundant, prepare the bath, once or twice, with the acid crystallised tin protochloride. With a very white deposit, but blistered and without adherence or thickness, replace the acid salt by the fused one. In the latter case, also diminish the proportion of tin salt, and increase that of pyrophosphate; a great deal of the success of the operation depends upon the quality of the pyrophosphate. When a tinning bath has been worked for a long time, decant the liquor to separate the zinc pyrophosphate formed. And when, after several years, the solution is entirely used up from the alteration of the salts, it should be kept in preserving tubs, where the objects to be tinned are put after cleansing.

Tinning Brass or Copper.—(*a*) Plates or vessels of brass or copper, boiled with a solution of stannate of potash, mixed with turnings of tin, become, in the course of a few minutes, covered with a firmly-attached layer of pure tin.

(*b*) A similar effect is produced by boiling the articles with tin filings and caustic alkali, or cream of tartar. In the above way chemical vessels made of copper or brass may be easily and perfectly tinned.

(*c*) Copper vessels must be well cleansed; and then a sufficient quantity of tin with sal ammoniac is put therein and brought into fusion, and the copper vessel is moved about. A little rosin is sometimes added. The sal ammoniac prevents the copper from scaling, and causes the tin to be fixed wherever it touches.

(*d*) Boil 6 lb. cream of tartar, 4 gal. water, and 8 lb. grain tin or tin shavings. After the materials have boiled a sufficient time, the substance to be tinned is put therein, and the boiling is continued, when the tin is precipitated in its metallic form.

Argentine.—Argentine is a name given to tin precipitated by galvanic action from its solution. This material is usually obtained by immersing plates of zinc in a solution of tin containing 6 grm. (about 90 gr.) of the metal to the litre (0·88 qt.). In this way tin scrap can be utilised. To apply the argentine according to Marino's process, a bath is prepared from argentine and acid potash tartrate rendered soluble by boric acid. Soda pyrophosphate, ammonium chloride, or caustic soda, may be substituted for the acid tartrate. The bath being prepared, the objects to be coated are plunged therein, first having been pickled and scoured, and they may be subjected to the action of an electric current. But a simple immersion is enough. The bath for this must be brought to ebullition, and objects of copper or brass or coated therewith may be immersed in it.

Retinning Old Copper Pans.—When all the repairing is complete, the bruises are taken out, and the bottoms of the stew-pans and saucepans are laid flat or made level, the preparation for retinning properly begins. Commence with the application of a coat of pure commercial muriatic acid to eat off or remove the dirt and the portions of the old or previous tinning. When the vessels have stood a sufficient time, they are thoroughly scoured inside with good sharp sand, with the addition of some common salt, and then washed clean, care being taken that all the old tin is off when burnt, and that nothing greasy gets inside. Then while the vessel is yet damp a coat of finely powdered sal ammoniac is sprinkled over the inside, and a coat of wet salt is carefully put on the outside to guard against the effects of the different gases from the fire.

Now take a quantity of block or ingot tin and slowly melt it in a ladle, being careful not to allow any part of it to become too hot or get burnt. When the tin is melted and ready, then warm and dry the vessel to be tinned, and pour a sufficient quantity of tin into it. Next take a sal ammoniac wad, and with it rub and agitate the liquid tin over the entire inside surface of the vessel until every part is well covered, and then pour out the bulk of the liquid tin. After heating the vessel to a uniform heat all over, take a wisp of clean, soft flax-tow, the hand first being protected by means of a glove which has had the tips of the fingers cut off as far as the first joint, and whisk it in a pan of powdered sal ammoniac; then with a light hand and a few quick motions, first around the left side and then the right, and then across the bottom, wipe out the residue of the tin, leaving only a clear bright coat on the surface of the vessel. Only by constant practice can this operation be accomplished or excellent results secured. Being a few months out of practice will seriously affect a man's proficiency in the sense of touch and cause him many unpleasant and annoying failures. While the tinning process is going on, a boy is busily scouring and preparing other vessels. The tinning process being over, the next in order is to scour each article with clean white sand on the outside to remove the salt, and inside any sal ammoniac that might be left. This scouring must be carefully done, and it is best to have a separate place for each operation, so that when the outside is cleaned off the inside can be scoured without fear of contamination from the salt; because if the outside scouring wisp should by mistake get on the inside the work would be spoiled and can scarcely ever be restored again, so it is best to keep the wisps far enough apart to ensure them from being taken up and used by mistake. After the sal ammoniac has been scoured off and the surface outside and inside is clean and bright, the articles are rinsed off in clear water and dried in clean, fine sawdust kept in a large box, and then stood around a large forge-fire to be dried more thoroughly. Next brush off the sawdust, and with a clean, soft linen or cotton rag and clean whiting, polish the inside; then with another rag and a little crocus polish the outside and the job is complete.

Tinning Brass Wire.—Have two baths, one containing the molten tin, kept at a proper temperature, the other a saturated solution of zinc chloride. Immerse the coil of brass wire in a boiling solution of caustic potash, and remove it to a bobbin, having a fixed spindle and one movable end. Pass the wire by means of suitable hard wood or brass deeply-grooved pulleys, so that it shall pass through the zinc chloride bath into the molten tin, and after immersion cause it to pass between the grooves of two pulleys, revolving in contact with each other, so that the grooves form a hole equal in size to the tinned wire; these will squeeze off any superfluous metal that may be carried up from the bath; carry forward the end and attach to it a fresh bobbin, and wind off at a speed that must be regulated by experience. The wire must be raised sufficiently in temperature before it will take the tin, and it must be properly cooled again before it reaches the final bobbin, which can be effected by placing it at a proper distance from the tin bath.

(*b*) A solution of tin perchloride is first prepared by passing washed chlorine gas into concentrated aqueous solution of tin salt, and expelling the excess of chlorine by gently warming it, then diluting it with 8 to 10 times its volume of water, and filtering it if necessary. The article, well pickled in dilute sulphuric acid, polished with sand and a steel scratch-brush, and rinsed with water, is loosely wound with a zinc wire, and immersed for 10–15 minutes, at the ordinary temperature, in the dilute solution of tin perchloride. When tinned in this way, it is raised, brushed with a scratch-brush, dried, and finally polished with whiting. Cast iron, wrought iron, steel, copper, brass, lead, and zinc can be tinned by this method.

(*c*) Put the wire with some tinfoil or scrap tin in a solution of cream of tartar and boil for ½ hour. The coating is very thin.

(*d*) Get some pure tin and melt in a ladle. Place a dish to hold about 6 in. of water on the ground. When tin is melted, hold ladle in a line with shoulder and pour gently into water, after which take out and put into a clean dish (copper is best), free from every kind of dirt and grease. Cover bottom of vessel with tin, put wire on top (the wire must be thoroughly cleansed), cover with another layer of tin, fill with pure water, and sprinkle cream of tartar over. You must judge yourself as to quantity; too much will blacken your wire and tin, too little will not take on the tin. Place your dish on fire. When boiling allow it to remain so for 20 minutes; the dish should have a cover to it.

(*e*) 1 part potash bitartrate, 2 of alum, and 2 of common salt, in 10–12 water; add pure tin filings. Boil the article in the solution. This avoids the great heat of molten tin.

Tinning Iron.—(*a*) Iron which is to be tinned must be previously steeped in acid materials, such as sour whey or distillers' wash; then scoured and dipped in melted tin, having been first rubbed over with a solution of sal ammoniac. The surface of the tin is prevented from calcining by covering it with a coat of fat.

(*b*) This process is of little importance as a protection for iron, as the layer of tin is a mere film, but it may be useful when thicker coats of tin are to be applied by other processes. For the bath, dissolve with the aid of heat, in an enamelled cast-iron kettle, ammonia-alum, 11 oz., and fused tin protochloride, ⅓ oz., in 4½ gal. soft water. The pieces of iron, previously cleansed and rinsed in cold water, are steeped in the solution as soon as it boils. They are immediately covered with a film of tin of a fine white dead lustre, which may be rendered bright by friction. The bath is maintained at the proper strength by small additions of fused tin protochloride. This bath is convenient for a preliminary tinning of zinc; when the ammonia-alum may be replaced by any other kind of alum, or by alumina sulphate; but for wrought and cast iron and steel this substitution cannot be made.

Tinning Iron Saucepans.—If the saucepan is an old one it must be put on the fire and allowed to get nearly red hot, which will get rid of all the grease; then make a pickle of the following proportions;—Oil of vitriol, ½ lb.; muriatic acid, ¼ lb.; water, 1 gal. If the saucepan can be filled so much the better, if not keep the pickle flowing over it for say 5 minutes, pour out, rinse with water, and scour well with sand or coke dust with a wisp of tow, rinse well with water; if the pan is clean it will be of an uniform grey colour, but if there are any red or black spots it must be pickled and scoured again till thoroughly clean. Have ready zinc chloride, that is, muriatic acid in which some sheet zinc has been dissolved, some powdered sal ammoniac, some tow, about 18 in. of iron rod ¼–⅜ in. thick, one end flattened out and bent up a little and filed clean, and some bar tin; dip a wisp of tow in the zinc chloride, then into the powdered sal ammoniac, taking up a good quantity, and rub well all over the inside. This must be done directly after the scouring, for if allowed to stand it will oxidise; put on the fire till hot enough to melt the tin, the end of the bar of tin being brushed over the heated part till melted; run down about half the bar, and with the flattened end of the iron rod rub the tin well over the surface, taking care not to heat too large a surface at once, nor to let it get too hot, which may be known by the tin getting discoloured, when some dry sal ammoniac must be thrown in. Having gone all over it, wipe lightly with a wisp of tow, just made warm enough that the tin does not stick to it; when cold scour well with sand and tow, rinsing with plenty of water.

Tinning Cast and Wrought Iron Pipes.—File bright the piece of iron required to be tinned, and mix up the following solution;—In a pennyworth of spirits of salts, put a piece of zinc the size of a shilling, the spirits of salts will eat it away; wet the places required to be tinned with the solution, then while wet use a copper-bit with fine solder, and it will immediately tin.

Tinning Iron Wire.—The following is Heeren's process for giving iron wire the appearance of silver. This is done by a thin film of tin. The iron wire is first placed in hydrochloric acid, in which is suspended a piece of zinc. It is afterwards placed in contact with a strip of zinc in a bath of 2 parts tartaric acid dissolved in 100 of water, to which is added 3 parts tin salt and 3 of soda. The wire should remain about 2 hours in this bath and then be removed, and made bright for polishing, or drawing through a polishing iron. By this galvanic method of tinning, wire which has been wound in a spiral, or iron of other shape, can be made quite white, which is an advantage over most other methods, where the wire is tinned in the fire and then drawn through a drawing plate.

Tin plate.—Tin plate can be classified, according to the iron used, as follows: Charcoal plate, puddled iron, coke plate, and steel plate. In a few works sheet iron is still made of iron refined with charcoal. Of course an excellent quality of pig iron must be used to make puddled iron of good and best quality. Steel plate is made of very tough steel made by different processes. The so-called charcoal tin is made by refining pig iron and scrap with charcoal, and is very dense and strong. For this reason tin plate made from it is rather harder to work, but will stand longer and is better than that made from softer iron. Only puddled iron is generally used for coke plate, since a better quality is rarely required for such tin.

The iron used in making tin plate is prepared as follows: The blooms, weighing 40–50 cwt., as they come from the puddling or refining furnaces, are first placed under steam hammers, then rolled into thin bars, which are cut up and tied in bundles. These bundles are strongly heated in the reheating furnace, thoroughly wrought, heated again, rolled into bars in calibrated rolls, then cut in lengths corresponding to the different sizes of plate, and called platins or plate iron. These bars are then rolled out with hard rollers into sheets, which are trimmed with huge scissors to the exact sizes met with in commerce. The sheets must be pickled to remove the coating of oxide (rust), either hydrochloric or sulphuric acid being used according to circumstances.

The material is rendered so hard and brittle by this treatment that it has to be annealed before proceeding to the next step, namely, smoothing and polishing. This is accomplished by heating in tightly closed boxes or muffles, the plates being packed tightly together. These muffles are placed on wagons and run in a warming furnace, where they are left 10–15 hours. The polishing is performed by drawing the sheets of iron, after they have been pickled and tempered, between polished rolls of hard cast steel heavily weighted.

To get a clean metallic surface, such as is requisite to receive the tin, the iron must be dipped repeatedly into quite dilute sulphuric or hydrochloric acid, then polished and scoured, each one separately, with sharp sand over the entire surface. It is now ready to receive the tin, and passes to the tinning room.

In this room are a number of kettles, all of the same height, placed in a row and heated with fires beneath them. They are called the grease kettle, the tinning kettle, the brush kettle, the fine tin or roller kettle, and the grease kettle. The different operations performed in these kettles take place in this order: The pickled and scoured plates are put in the first kettle and thoroughly coated with grease, usually pure tallow, but sometimes palm oil is used. Then it goes to the tin kettle, in which it is moved about until evenly tinned all over. From this it goes to the third kettle, also containing tin. Here each individual plate is taken out and brushed with an oakum brush or pad of hemp to remove the coarser particles. It is next put in the fine tin; then in the last kettle, that also contains hot grease, on a grating, or moved up and down in it by rollers. When the plates come from this kettle they are placed on racks to cool. The tinning is now completed, but they do not look very nice, owing to the adherent grease. To remove this they are drawn through three or four large boxes filled with slaked lime, sawdust, bran, or flour; flour is the best of all, for it cleans them better, and after it gets saturated with grease the flour can be used for cattle feed.

After the tin plates leave these boxes they go to the polishing bench to remove the dust. This bench consists of a table covered with woollen cloth, or a sheep pelt, and the sheets are rubbed singly with a rubber made of wool or sheepskin, which brings out the pure, fine lustre of the tin.

The tin is next assorted by a careful inspection of both sides, and classified as first, second, or third quality. Sheets that are imperfectly tinned are sent back to the tinning room, while the rest are packed in wooden boxes and the brand is burned on.

Attempts have been made to replace the fat with tin chloride, but tin plate made in this way was found to be inferior to that made by the old process, because it is far more prone to rust. At present scarcely any tin plate is made with tin chloride, but some manufacturers use this process for tinning cooking utensils.

Another improvement consists in passing the tin, as it comes dripping from the last bath of melted tin, between rollers that squeeze off the excess of tin and leave a uniform coating of any desired thickness according as they are set close or far apart.

Elm is the wood generally used for boxing tin.

Tinning Zinc.—The proportions of the bath are as follows:—Distilled water, 66 gal.; soda pyrophosphate, 11 lb.; fused tin protochloride, 35 oz. A thin tinning is obtained by simple dipping, and one of any thickness by the aid of the battery.

Zinc Deposits.—Zinc is deposited by the wet way and by the battery. The dead lustre colour is a grey blueish-white. Precipitate a soluble zinc salt by ammonia; this precipitate redissolved in an excess of alkali gives a satisfactory bath; any kind of zinc salt may also be dissolved in potassium cyanide or a soluble sulphite. These deposits are entirely different as regards the durability, from the so-called galvanising, when cleansed iron is plunged into a bath of molten zinc, and is thus protected against oxidation for a long time, which is not the case with electro-deposited zinc.

For depositing upon copper or brass, in the wet way, prepare finely-divided zinc, by pouring the molten metal into a previously strongly heated iron mortar, and stirring until nearly cold. The powdered zinc thus obtained is placed in a porcelain vessel, and to it is added a concentrated solution of sal ammoniac. This mixture is heated to boiling; and the copper or brass objects to be coated with zinc, but previously well cleansed, even with an acid, are then placed in a liquid where they obtain a brilliantly white adhering layer of zinc.

Coating Brass and Copper.—It is not often that it is necessary to coat either brass or copper with zinc, the ordinary "silvering" (i. e., washing with tin) answering most effectually under all ordinary circumstances. Still, a method of coating them with zinc may be found useful. The usual process of boiling the brass or copper articles in a concentrated solution of ammonium chloride containing shavings of zinc is superseded by a method in which an alkaline solution of zinc oxide is found to give a better result in less time. An excess of powdered zinc is placed in a boiling solution of potash or caustic soda. The brass or copper articles after cleaning are then immersed in the solution, and after a minute's immersion they may be withdrawn covered with a coat of zinc. By this process an easy method of converting copper plates into pinchbeck is furnished to the mechanic. The copper plates thinly coated with zinc are heated, preferably in an oil bath, to 250°–285° F., when the coating of zinc will be found to combine with the copper, forming an excellent pinchbeck, more or less of a golden colour. When the desired hue is attained, the plates must be immediately cooled in water or any other suitable liquid. The process is also employed for making Zamboni's piles (dry voltaic piles). Very thin pieces of sheet copper are coated with zinc, and the latter is subsequently removed from one side of the copper by means of hydrochloric acid. Piles made from discs of the metals thus prepared are said to give much better results (are more active electromotors) than layers of gold leaf or the other materials used in constructing Zamboni piles.

Galvanising Iron.—Sheet iron, iron castings, and the like, are first cleaned and scoured by immersion in a bath of water, acidulated with sulphuric acid, heated in a leaden vessel, or used cold in a wooden one, to remove the oxide. The pieces are then thrown into cold water, and taken out one at a time to be scoured with sand and water with a piece of cork or the husk of the coconut, the ends of the fibres serving as a brush. The pieces are then returned to cold water. Pure zinc, covered with a thick layer of sal ammoniac is then melted in a bath, and the iron, if in sheets, is dipped several sheets at a time in a cradle or grating. The sheets are raised slowly to allow of draining, then immediately thrown into cold water; on removal, the work is finished by wiping dry. Thick pieces are heated in a reverberatory furnace before being placed in the bath, to prevent cooling the zinc. Chains are similarly treated, and on removal from the zinc are shaken until cold to avoid soldering the links together. Nails and small articles are dipped in muriatic acid, and dried in a reverberatory furnace; next, thrown into zinc covered with sal ammoniac, left for a minute, and taken out slowly with an iron skimmer; they come out in a mass soldered together, and to separate them are placed in a crucible surrounded with charcoal powder, then heated to redness and shaken about until cold for separation. Wire is reeled through the zinc, into which it is forced to dip by a fork or other contrivance. The zinc is melted in a crucible just a little beyond the point of fusion, and is always covered with a thick coat of sal ammoniac, for the purpose of preventing waste of zinc and preparing the metal to be covered. Wrought-iron baths welded at the angles succeed much better than cast-iron, lined with clay. By another system the sheets of iron are pickled, scoured, and cleaned just as for ordinary tinning. A large wooden bath is then half filled with a dilute solution of muriate of tin, prepared by dissolving metallic tin in concentrated muriatic acid, which takes 2 or 3 days, and 2 qt. of the saturated solution are added to 300 or 400 gal. of the water contained in the bath. Over the bottom of the bath is spread a thin layer of finely-granulated zinc, then a cleaned iron plate, and so on—a layer of finely-granulated zinc and a cleaned iron plate alternately, until the bath is full; the zinc and iron, together with the fluid, constitute a weak galvanic battery, and the tin is deposited from the solution, so as to coat the iron with a dull uniform layer of metallic tin in about 2 hours. Whilst this is being done a wrought-iron bath, containing fluid zinc, is being prepared, the melted metal is covered with sal ammoniac, mixed with earthy matter, to lessen the volatilisation of the sal ammoniac, which becomes as fluid as treacle. Two iron rollers, immersed below the surface of the zinc, are fixed to the bath, and are driven by machinery to carry the plates through the fluid metal at a determined velocity. The plates are now received one by one from the tinning bath, drained for a short time, and passed at once, still wet, through the zinc, by means of rollers; the plates thus take a regular and smooth layer of zinc, which, owing to the presence of tin beneath, assumes the natural crystalline character, giving the plates the well-known appearance.

In Cleveland, Ohio, the galvanising of sheet iron is carried on in the following manner: The plates are first placed in a bath of dilute sulphuric acid, into which steam is led. The acid is contained in a wooden vat, and the plates are placed on their edges and kept separate from each other. They are removed from this bath and placed in another vat, through which water is flowing. From this vat they are removed one by one, examined, any unevenness is scraped off them, and they are again washed in another vat with water, and are then placed edgewise on a wagon, which carries 20 plates, leaving a space ½ in. between each plate, and are run on this wagon into a drying kiln. This kiln takes two such wagons at a time, and the wagons are run in at one end and out at the other. It is heated by flues passing under the floor and round the sides. The drying and heating takes about 20 minutes. The zinc bath is made of forged iron, 8–12 ft. long, 2 ft. broad, and 3 ft. 6 in. to 4 ft. 2 in. deep, and holds 18–25 tons of molten zinc. This pan is set upon masonry, and is surrounded by a 12 in. wall of firebrick, leaving a space of 8 in. between the wall and the iron sides of the bath, the height of the wall reaching just to the height of the pan. In this space between the pan and the brickwork a coke fire is maintained, two rows of air-holes being let into the lower part of the wall, the lower row serving to remove the ashes. A bar of iron divides the bath longitudinally into two halves; this bar dips a few inches below the surface of the zinc, and projects about 3 in. above the surface. On one side of the bar the zinc is covered by a ½ in. coating of sal ammoniac, and on the other side of the bar by a 2 in. coating of damp sand. The iron sheet is taken from the drying kiln, and is dipped perpendicularly, its long edge first, slowly into the bath on the sal ammoniac side of the dividing bar, and is brought up on the other side of the bar through the sand. It is then gripped by a pair of tongs by one corner, and drawn slowly out of the pan by a rope passing over a pulley in the roof, and wound upon a hand-winch. The adhering drops of zinc are removed, and the plate is laid upon a table; the sand is rubbed off with a piece of sacking, and then, if found to be perfect, it is stamped and packed. It remains in the bath about one minute.

Galvanoplasm. Thick Deposits.—Galvanoplasm consists of deposits with sufficient thickness to form a resisting body, which may be separated from the objects serving as moulds, and which will preserve the shape and dimensions of the model. A statue of plaster of Paris, wood sculpture, an impress in wax, fruit, and similar things, may, after certain preparations, be covered with electro-deposits, for instance, which will give a deposit representing the same shape and dimensions. In galvanoplastic operations copper is almost exclusively employed. It is possible to have the deposits entirely of silver and gold; but these are exceptions, on account of the cost of the materials and of the difficulties of the operation. The following is a summary of the usual requirements;—1. To apply upon a metallic surface conductor of electricity, a deposit of copper adhering to the metal underneath. 2. The above operation being completed, the two metals must be separated in such a manner that they will furnish two identical productions, one of which will be in relief, and the other hollow, for casts of medals, &c. 3. To apply the electro-deposits upon substances not naturally conductors of electricity, but rendered so by the process of metallisation; upon ornaments of plaster of Paris, wax, glass, or porcelain, or upon leaves, fruits, and insects. 4. After the deposit to separate the non-metallic model to have a perfect copper copy of it. For reproduction of type in stearine, gutta-percha, gelatine. 5. Or, if it is impossible to apply the electro-deposit of copper directly upon the model, make moulds upon which a greater or less number of copies may be obtained. This is the general case:—The imprint of the model is taken with a plastic substance, which is rendered a conductor of electricity, and upon which the galvanoplastic deposit is effected.

The Baths.—(1) Put into a vessel, made of glass, stoneware, porcelain, gutta-percha, or lead, a certain quantity of water, to which is added 8–10 per cent. of sulphuric acid. If in a glass vessel, or one lined with gutta-percha, pour in the acid slowly and stir all the time, otherwise the acid, which is much denser than water, falls to the bottom, and slowly combining with the surrounding water, may cause an increase of temperature sufficient to break the glass or melt the gutta-percha.

(2) Dissolve in this liquor as much copper sulphate as it will absorb at the ordinary temperature. Stir frequently with a glass or wooden rod, to mix the solution; or the copper sulphate may be put into a perforated ladle of copper or stoneware, or into a bag of cloth, fixed near the surface of the liquid. When the liquid refuses to absorb any more crystals, it is saturated, and marks about 25° B. Baths of copper sulphate, while they are working, must always be kept saturated; new copper sulphate must be introduced to replace that decomposed and forming the metallic deposit; for this purpose suspend from the top of the vessel, and in the upper portion of the liquid, bags filled with crystals of copper sulphate. It is necessary to use good copper sulphate; the best is in crystals, semi-transparent, and of a fine blue colour. Its solution is also a pure blue. These baths are always used cold, and are kept in vessels of shapes adapted to the wants of the operator. Stoneware, porcelain, and glass are the best materials for the purpose; but as it is difficult to find vessels sufficiently large, wooden troughs covered inside with coats of gutta-percha, marine glue, or with a sheet of lead, are used, painted with resist varnish.

Deposits by Separate Batteries.—After proper preliminary operations, the object which is to receive the deposit is connected with the conducting wire attached to the negative pole of the battery, zinc generally, and immersed in the solution; and the conducting wire starting from the positive pole, carbon or copper, is attached to a foil or plate of copper, and this anode is placed in the liquor parallel to the object connected with the other pole. This plate should have a surface at least equal to that of the article to be covered. The deposit will begin immediately, and its progress may be seen by removing the object from the solution. If upon a clean metallic substance, the deposit of copper will be instantaneous on every part of it; if, on the contrary, the surface only moderately conducts the electricity, as graphite, the deposits will begin at the points touched by the conducting wire, and then proceed forward. With a little practice it is easy to ascertain whether the intensity of the current corresponds to the surfaces to be covered. The operation will be slow with a weak current, but there is no other inconvenience, unless the substance of the mould is alterable, like gelatine. Too intense a current results in a granular deposit, of which the particles have little cohesion between themselves, and no adherence to the mould.

Simple Apparatus for Amateurs.—Place the solution of copper sulphate in a stoneware, earthenware, or porcelain vessel, in the centre of which stands a porous cell filled with water with 2 or 3 per cent. of sulphuric acid, and 1 per cent. of amalgamating salt. This liquid must surround an inner cylinder of zinc, upon the top of which rests a circle of brass wire, by two crossed bars soldered or fixed in four notches on the top of the zinc cylinder. Suspend from this circular framework, projecting over the copper solution, a certain number of objects or moulds, immersed in the liquid in such a way as to have their faces to be covered near and opposite to the cell. Two small hair bags filled with copper sulphate crystals, should be attached to the upper edge of the vessel.

Large Apparatus.—To cover large surfaces, use a bath contained in a large wooden trough, lined inside with gutta-percha, or lead, or other substance unacted upon by the bath. In the middle of the trough dispose a row of cells close to each other, and each with its zinc cylinder. Connect a thin metallic ribbon with all the binding screws of the cylinders, in contact at its extremities with two metallic bands on the ledges of the trough. The metallic rods to support the moulds are placed in contact with the metallic bands of the ledges, and therefore in connection with the zincs. If the objects are in high relief, use a circular trough, place the cells in a circle, and the mould to be covered in the centre. Whatever the shape of the mould, its position should now and then be changed, because the lower layers of the bath give more abundant deposits, owing to the difference of specific gravity of the layers more or less charged with sulphate. As far as practicable, maintain the liquids in the bath and in the cells at the same level; or it is better to have that of the bath slightly above that of the cell, to prevent the solution of zinc from mixing with the copper bath.

Porous Cells.—Pipeclay, pasteboard, bladder, gold-beater's skin, parchment, sail-cloth, and certain kinds of wood may be employed, but nothing equals porcelain clay, submitted to a certain heat, which hardens the paste without destroying its porosity. Vases made with this material are just porous enough, and resist the action of concentrated acids.

Batteries.—The battery will work well for 24 hours; and, for four consecutive days, it will only be necessary to add small quantities of acid and amalgamating salt, in proportion to the volume of the cells. Stir the mixture each time with a glass rod. The fifth day, throw away all the exciting liquors, and substitute fresh ones, otherwise the zinc salt will be so abundant as to crystallise upon the zincs and the cells. A cell may be clogged in two ways, (1) by the zinc sulphate, which having an insufficiency of water, crystallises in the pores; in this case boil the cells in water acidulated by sulphuric acid. (2) By deposits of copper caused by bad working; dip the cells in aquafortis until all the copper is dissolved, and rinse in plenty of water afterwards. It is also possible to clean cells by keeping them filled with water, which, escaping through the pores, pushes out the salts and the acids with which they are clogged. Cast zinc will work, but is far inferior to laminated zinc, which will be uniformly corroded instead of being perforated. It sometimes happens that zinc is scarcely attacked, even by concentrated liquors, and that a multitude of small cavities are engraved on its surface. It also becomes covered with a blackish-grey crust, and no electricity is disengaged. These inconveniences occur when the zinc is too rich in lead.

Amalgamating Salt.—To avoid the solution of the zinc when the apparatus is not at work, cleanse it in dilute hydrochloric acid, and then amalgamate it by rolling the cylinders in a trough filled with mercury.

Acid Baths.—When a bath contains too weak a solution of copper sulphate, the electro-deposit is pulverulent, black and irregular. The same inconvenience occurs when the liquors become too acid, because they do not dissolve enough copper sulphate. When the bath is too acid, add copper carbonate until effervescence no longer takes place. The bath should then be acidified anew to increase its conducting power. The copper carbonate may be replaced by the oxide of the metal, which dissolves without effervescence. If, after very long use, a bath becomes overloaded with free acid and zinc sulphate, there is no remedy but to start a fresh one.

Placing the Pieces in the Bath.—The depth of the bath should be sufficient to have a little liquor above and below the moulds. If the moulds are lighter than the solution of copper sulphate, sink them with lead pieces covered with varnish, with stones, or other non-conductors of electricity. When the object to be covered is metallic, and unacted upon by the solution of copper sulphate, attach the conducting wire to any part of its surface, and it will be rapidly covered with a uniform deposit; if the mould is a non-conductor of electricity, and has been covered with some conducting substance, such as plumbago, bronze powder, or reduced silver, multiply the points of contact, as much as practicable, of the electrode, by uniting the connecting wire with a number of fine copper wires, and making their bent extremities touch the mould at various places. This method gives a greater rapidity of operation, and a uniform thickness of deposit. It is especially necessary for moulds having deeply indented surfaces. As soon as the surface is entirely covered, remove the supplementary wires. If only one face of the mould is to receive the deposit, protect the other surfaces by a resist varnish, melted yellow wax, or softened gutta-percha.

Adhesive Deposits upon Metals.—Metals are unequally qualified to receive the galvanoplastic deposit; and some are naturally unfit for it. For instance, wrought and cast iron, steel, and zinc, as soon as immersed in the solution of copper sulphate, and without the aid of electricity, decompose the salt, and are coated with a muddy precipitate of copper without adherence. It is necessary to give them previously a thick coat of copper in the bath of double salts before submitting them to the action of the sulphate. Tin, although presenting these inconveniences in a much less degree, should also be copper electroplated in the solutions of double salts before going into the bath. When the metal to be covered is unacted upon by the bath, cleanse it well, and submit it to the action of the current, which will give a rapid and uniform deposit; this should not be too thick, otherwise the surfaces may have a coarse appearance, which impairs the fineness of the lines of the mould. With a good bath, and a well-regulated electric current, the delicacy of the pattern will not be defaced by a copper coat having the thickness of stout writing paper. A bright lustre may be obtained by scratch-brushing or burnishing; or by a passage through aquafortis and soot, and afterwards through the compound acids for a bright lustre.

Dead Lustre Gilding by Galvanoplastic Deposit.—Adhering galvanoplastic deposits give a very cheap and handsome gilding with a dead lustre, which, although not equal in durability, has the appearance of that obtained with mercury. Having cleansed the mould if metallic, or rendered it a conductor if non-metallic, immerse it in the solution of copper sulphate, and allow the deposit to acquire a dead lustre slightly in excess of that desired. After this operation, which may last 2 to 6 hours, remove the article from the bath, rinse it in plenty of water, and pass it rapidly through the compound acids for a bright lustre, which diminish the previous dulness of the appearance. Next rinse in fresh water; steep in a mercurial solution similar to that employed for gilding by dipping; rinse again; and immerse in an electro-gilding bath made of,—Distilled water, $2\frac{1}{5}$ gal.; soda phosphate, 21 oz.; soda bisulphite, $3\frac{1}{2}$ oz.; potassium cyanide, $\frac{2}{3}$ oz; gold, for neutral chloride, $\frac{1}{3}$ oz. At first, the current is rendered sufficiently intense by dipping the platinum anode in deeply; afterwards the intensity is diminished by partly withdrawing the anode until the entire shade of gold is obtained. This gilding requires but little gold, as the frosty dead lustre comes from the copper. When the lustre of the copper is very fine and velvety, dispense with the dipping into the compound acids, but the rapid passage through the mercurial solution is always desirable. If the deposited gold is not uniform, or appears cloudy, it is proof of an imperfect deposit in the bath, or of an insufficient steeping in the compound acids. The piece should then be removed from the bath, washed in a tepid solution of potassium cyanide, rinsed in fresh water, dipped in the solution of nitrate of binoxide of mercury, and electro-gilded anew. This gilding bears burnishing well; avoid acid waters and soap, which will produce a red polish, and use only the fresh solutions of linseed, or of marshmallow root. The tone of gold thus obtained is richer, deeper, and more durable than that produced upon frosted silver, the latter being recognised by the green colour of the burnished parts. This kind of deposit may be employed for binding substances together, because the covering coat will be continuous.

Galvanoplastic Deposits without Adhesion.—After thoroughly cleaning the pattern, rub it with a brush charged with plumbago, or with a soft brush slightly greased by a tallow candle. The film of fatty substance should not be seen at all. The deposit obtained represents an inverted image of the pattern, and the raised parts become hollow. Remove the mould, and perform the same operation upon the deposit; this second deposit is the accurate reproduction of the first pattern.

DEPOSITS UPON NON-METALLIC SUBSTANCES.—By this process porcelain, crystal, plaster of Paris, wood, flowers, fruits, animals, and the most delicate insects may be coated. These substances have no conductive power for electricity; it is, therefore, necessary to metallise them.

Metallisation.—This coat should be so thin as not to alter the shape or the minutest parts of the model.

Plumbago (graphite) is generally preferred, and in most cases its conducting power is sufficient; it may be applied in films thin enough not to impair the sharpness of the mould. The plumbago found in the trade is rarely pure. Remove the impurities by digesting for 24 hours paste made of plumbago and water, with hydrochloric acid. Several washings with water, and slow drying in a stove, finish the operation. If the plumbago is in large lumps, it should be powdered and passed through a silk sieve. The conducting power of this substance is sufficient when the surfaces are not deeply indented; but the mould should be rough enough for the plumbago to stick to it.

Gilt Plumbago has a conducting power much greater than that of the ordinary substance. Prepare as follows:—In $1\frac{3}{4}$ pint sulphuric ether dissolve $\frac{1}{3}$ oz. gold chloride, and thoroughly mingle with it 18--20 oz. good plumbago. Then pour into a shallow porcelain vessel, and expose to the action of air and light. After a few hours, the ether completely volatilises; stir the powder now and then with a glass spatula. Finish the drying in a stove.

Silvered Plumbago.—Dissolve 3 oz. crystallised silver nitrate in 3 pints distilled water; mix this solution with 2 lb. good plumbago. Dry in a porcelain dish, and then calcine at a red heat in a covered crucible. After cooling, powder and sift. Plumbago thus metallised conducts electricity nearly as well as a metal, although it is very expensive. Bronze powder mixed with plumbago is also used.

Rendering Moulds Impervious to Liquids.—Porous substances, before being coated with plumbago, are submitted to a previous operation, to render them impervious, by covering them with a coat of varnish, or by saturating them with wax, tallow, or stearine. For instance, with a plaster cast, cut a groove on the rim of the mould, place in it a brass wire, twist the ends, which must be long enough to hold the cast by. The cast, having been previously dried, is then dipped into a bath of stearine kept at a temperature of 180°–212° F., and a number of bubbles of air will escape from the mould to the surface. When the production of air-bubbles is considerably diminished, remove the cast from the bath. When the cast is tepid, cover it with powdered plumbago, and let it get quite cold. Then, after breathing upon it, rub thoroughly with a brush covered with plumbago; and be careful that the surfaces are completely black and bright, without grey or whitish spots. When the mould is very undercut, it is difficult to employ plumbago. In such cases metallise the whole, or the deep parts only, by the wet way. Soft brushes should not be used for rubbing plumbago. When the substances to be metallised are not porous, such as glass, porcelain, stoneware, horn, and ivory, cover them with a thin coat of varnish, which, when nearly dry, receives the plumbago.

Metallisation of Ceramic Articles.—After having varnished the portions of the piece to be covered, cover them with very finely laminated foils of lead, which bend to all desired shapes; then connect a brass conducting wire with the lead, and dip the whole into the bath; copper is immediately deposited upon the metallic parts. Thus glass vases may be entirely covered with copper, upon which deposit layers of gold or silver. The chaser may penetrate with his tool to different depths, and uncover one after the other, first the layer of silver, next that of copper, and at last the crystal itself. The vase will appear as if set in a net of various colours. For very fine work, the gold ornament first painted with the pencil, and fixed in the usual manner by heating in a muffle, is put in contact with a very thin conducting wire, and the whole is immersed in a copper, silver, or gold bath, where the deposit takes place in the same manner as upon an ordinary metal, and the adherence is as perfect as that of the film of gold upon the porcelain. The deposit is afterwards polished, chased, or ornamented on the lathe.

Metallisation by the Wet Way.—Silver, gold, and platinum, reduced from their solutions, have an excellent conducting power. Silver is generally preferred, and its nitrate is dissolved in certain liquids, variable with the substances to be covered. Apply the solution with a pencil upon the mould, and let it dry; repeat the operation two or three times. Lastly, expose the mould to the action of the sunlight, or of hydrogen, or fix it to the top of a box which closes hermetically, and at the bottom of which is a porcelain dish holding a small quantity of a concentrated solution of phosphorus in carbon bisulphide. After a few hours this solution completely evaporates, and reduces to the metallic state the silver nitrate covering the mould, which becomes black, and is then ready for the bath. When used to metallise wood, porcelain, and other resisting substances, dissolve 1 part silver nitrate in 20 of distilled water. With fatty or resinous materials, which water will not wet, use aqua ammonia. With very delicate articles, which will not bear a long manipulation, make the solution in alcohol, which evaporates rapidly. Concentrated alcohol dissolves silver nitrate but slightly; but enough will be dissolved for metallising flowers, leaves, and similar articles, if the solution is aided by grinding in a mortar. If the conducting wire is fixed to the mould before the metallisation, the wire must be of gold, silver, or platinum, as the other metals rapidly decompose the solution of silver nitrate; but brass and copper wires may be employed when the metallisation is completed, after the reduction by phosphorus.

Solution of Phosphorus in Carbon Bisulphide.—Half fill a glass stoppered bottle with a large neck with bisulphide, then gradually introduce the phosphorus gently dried with blotting paper, and shake the bottle now and then. Phosphorus is added until no more dissolves. This preparation requires great care in the handling, because in drying upon combustible materials it takes fire spontaneously.

Plaster of Paris Moulds.—After the original model, say a medal, has been thoroughly rubbed with soap or plumbago, wrap round the rim a piece of stout paper, or thin lead foil, and bind it in such a manner that the article to be copied, face upwards, is at the bottom of the box thus formed. Then in a vessel filled with a sufficient quantity of water, sprinkle fine plaster of Paris until the last portions reach the level of the water. After waiting for one or two minutes, stir, and the thin resulting paste must be employed immediately. With a painter's brush give a thin coat of this paste, and press into all the recesses; this is to expel the air; then pour the remainder of the paste up to a proper height, and allow it to set. After a few minutes the plaster hardens, and may be separated from the paper. Scrape off what has run between the paper and the rim of the medal, and the plaster cast will separate from the model. Plaster of Paris moulds cannot be introduced into the bath without having been previously rendered impervious.

Moulding with Stearine and Wax.—Stearine is melted and poured upon the model when it is going to set. When stearine is too new or dry, it crystallises in cooling, and this impairs the beauty of the cast. In such case it should be mixed with a few drops of olive oil, or with tallow, or suet; if it is made too fat, it will remain soft and difficult to separate from the mould. It should then be mixed with virgin wax or spermaceti. As stearine contracts considerably by cooling, its employment must be avoided when the copies are required to be perfectly accurate. When it is desired to make a cast with stearine of a plaster model, the latter should be thoroughly saturated with water or stearine beforehand, and should also be perfectly coated with plumbago before the melted substance is poured upon it, otherwise the two will stick together, and it will not be possible to separate the cast from the model. Wax may also be employed in the same manner, but its price and want of hardness interfere with its application.

Moulding with Fusible Metal.—This metal is a perfect conductor of electricity, and therefore well adapted to the production of homogeneous deposits of equal thickness; it is, however, seldom employed, on account of the difficulty of the operation, of its crystalline texture, and of the presence of air-bubbles.

Fusible alloys are:—(*a*) Pure lead, 2 parts in weight; tin, 3; bismuth, 5; fusible at 212° F. (*b*) Pure lead, 5 parts in weight; tin, 3; bismuth 8; fusible at 180°–190° F. (*c*) Pure lead, 2 parts in weight; tin, 3; bismuth, 5; mercury, 1; fusible at 158° F. (*d*) Pure lead, 5 parts in weight; tin, 3; bismuth, 5; mercury, 2; fusible at 125° F. For those alloys without mercury, the component metals may be melted together; when mercury is employed, it should be added when the three other melted metals have been removed from the fire. To obtain a thorough mixture the alloy should be stirred with an iron rod, or melted over and cast several times.

Run the metal into a small dish, remove the oxide with a card, and then apply the model, give it a few taps when the setting takes place; or put the model into the dish, and pour the clean alloy upon it. Or, put the medal at the bottom of a small box of iron or copper, and bury half its thickness in plaster of Paris; then, cover the medal with the cold fusible alloy, and apply heat until melted, when it is allowed to cool off. It is easy to separate the medal from the fusible alloy, as the portion protected by the plaster of Paris may then be grasped. A well-made cast of fusible alloy is the best mould for galvanoplastic operations with silver and gold. Alloys containing mercury should not be used for taking casts from metallic medals, iron excepted, which would be amalgamated and injured. Copper deposits obtained upon such alloys are very brittle. Melted sulphur produces very neat and sharp casts; it is, however, very difficult to get it metallised, and it transforms the deposit of copper into sulphide.

Moulding with Gelatine.—In certain conditions, the elasticity of gelatine and gutta-percha allows of removing them from undercut or highly-wrought parts, and they reacquire the shape and position they had before the removal. This property is found in gelatine to a higher degree than in gutta-percha, but it requires a very rapid deposit, otherwise it will swell and be partly dissolved by too long an immersion in the solution of copper sulphate. Put sufficient colourless gelatine in cold water, and let it swell there for about 24 hours; then drain off the water, and heat the gelatine upon a water bath until it has become of a syrupy consistency; it is then ready to be poured upon the object, which must be encased in a box of pasteboard or of thin lead. After cooling for about 12 hours, separate the cast from the object. To enable the gelatine to remain longer in the bath without alteration, use one of the following mixtures:—

(*a*) Dissolve the best gelatine in hot water, and add $\frac{1}{50}$ of the weight of gelatine in tannic acid and the same quantity of rock candy; then mix the whole thoroughly, and pour upon the model in its box. After a few hours the gelatine may be easily separated from the object.

(*b*) A mould having been made with gelatine alone, pour on it a solution of water holding 10 per cent. potash bichromate, and after draining, expose the mould to the action of the sun.

(*c*) Beat, in 2 pints distilled water, the whites of 3 eggs, filter, and cover the entire surface of the gelatine mould with this liquid. After drying, operate with the solution of potash bichromate, as in (*b*).

(*d*) Pour some varnish upon the gelatine mould, drain carefully, and let it dry. The best varnish for the purpose is a solution of rubber in benzole, or in carbon bisulphide. The mould must be metallised, and, when in the bath, submitted to a galvanic current of great intensity at the beginning. When the entire surface is covered with the copper deposit, and swelling is no longer to be feared, the intensity may be reduced.

Moulding with Gutta-percha.—Gutta-percha is entirely insoluble in water, in weak acids, and in the solution of copper sulphate. After purification in boiling water, plates of various thicknesses or lumps are formed. A quantity sufficient for the intended mould is cut and put in cold water, which is gradually heated, until it is soft enough to be kneaded with the fingers like dough. After having pulled the gutta-percha in every direction, the edges are turned in so as to form a kind of half ball, the convex and smooth surface of which is then applied upon the middle of the model. Then the gutta-percha is spread over and forced to penetrate the details of the object. The kneading is continued so long as the material remains sufficiently soft, when it is allowed to cool. As soon as it is lukewarm, the gutta-percha is separated from the model, and dipped into cold water, when it hardens, and may then be handled without danger of impairing its accuracy.

Moulding with the Press.—After the object has been carefully coated with plumbago or tallow, it is put square and firm upon the table of the press, and surrounded with a ring or frame of iron, which should be a little higher than the most raised parts of the object. A piece of gutta-percha, at least double the thickness of the pattern, is cut so as to fill the ring or frame of iron, and then heated, on one of its faces only, before a bright fire. When about two-thirds of its thickness have been softened, it is to be placed, soft portion downwards, in the iron ring or frame, and the whole covered with a block of metal exactly fitting. The screw to the press is made to act slowly at first, but with gradually increased force, as the gutta-percha becomes harder and more resisting.

Moulding with a Counter-mould.—Cast a thin block of lead upon sand; hollow out approximately with a graver the places corresponding to the reliefs of the pattern, bearing in mind the desired thickness of the gutta-percha. Spread over the pattern a plate of gutta-percha of the same thickness all through; upon this place the lead block; compress by the screw press. This process produces excellent results.

Moulding in the Stove.—This is convenient for brittle articles of plaster of Paris, marble, or alabaster. The pattern is put upon a dish of iron or earthenware, a ball of gutta-percha is placed in the middle of the object to be moulded, and the whole is placed in a stove, where the temperature is just sufficient to melt the gutta-percha, which softens and penetrates all the details; when it has sunk completely, remove it from the stove, and allow to cool off until it still retains sufficient elasticity to be separated from the pattern.

Moulding by Hand.—The foregoing process does not suit objects which will not bear the heat of the stove; for such articles heat the gutta-percha slowly until it becomes a semi-fluid paste; pour a sufficient quantity of it upon the pattern previously placed in an iron frame or ring. After a few minutes, knead it, with wet or oiled fingers, to make it penetrate all the details of the pattern until it scarcely yields to the pressure. In removing the mould from the pattern, cut off all the useless parts of the gutta-percha, and especially those which may have passed under the pattern and bind it. Then the proper position and shape of the covered pattern must be ascertained, so as not to break the model, or tear the gutta-percha. In moulding with the press, gutta-percha of the best quality is generally employed. For moulding by sinking or kneading, gutta-percha should be mixed with certain substances to increase its fusibility, such as linseed oil, lard, tallow, or yellow wax. Their proportions should never be over one-third of the total weight. The mixture with linseed oil is made by heating in a kettle 1 part linseed oil, and when its temperature has reached 190°–212° F., add gradually, and stir in 2 parts gutta-percha cut into small pieces. When the whole is in a pasty form, and begins to swell up with the production of thick fumes, remove the kettle from the fire, and throw its contents into a large volume of cold water, where, without loss of time, the paste must be well kneaded. While still hot, place it upon a slab of marble or stone; it may afterwards be rolled between middling warm rollers. Gutta-percha may be used for an indefinite length of time. Models of plaster of Paris, from which moulds of fusible metal or of gelatine are to be taken, will stand the operation much better if they have been hardened by being saturated with boiled linseed oil, to which a certain proportion of dryer has been added. They must be oiled again just before pouring the gelatine over them.

Deposits on Undercut Patterns which are Sacrificed.—A cast of a human head in plaster of Paris may be rendered impervious, and then metallised. After a deposit of copper has been effected on its surface, remove the plaster by boiling, and breaking it through the opening of the neck. The copper mould thus obtained, after being slightly greased inside, serves as a galvanoplastic trough, which is to be filled with the solution of copper sulphate. Suspend bags filled with crystals of blue vitriol to the edges, and with a separate battery and soluble anode, or with a porous cell placed inside the mould, which is connected with the zinc, another deposit of copper takes place in the cavity. When the thickness of the metal is sufficient, strip off the mould or first deposit. This process is expensive, but gives sure results with large patterns having large raised parts. With small or narrow, or very crooked objects, moulds in several parts must be used, although the seams require mending.

Method for Articles in High Relief with Gutta-percha Moulds.—If it is required to imitate a statue, or other large article, commence by making with gutta-percha a mould in several pieces, which, by means of proper marks, may be united together, and form a perfect hollow mould of the pattern. Cover all these parts carefully with plumbago. Make a skeleton with platinum wires, to represent the outline of the pattern; this must be smaller than the mould, as it has to be suspended in it without any point of contact. The skeleton is to be enclosed in the metallised gutta-percha mould, and the whole immersed in the galvanoplastic bath; connect the inner surface of the mould with the negative pole of the battery, and the skeleton of platinum wires, which should have no point of contact with the metallised surface of the mould, with the positive pole; this decomposes the solution of copper sulphate, which must be placed in the mould. When the deposit has reached the proper thickness, remove the gutta-percha mould, inside which will be found the statue, which may be finished at a very small expense. Lead wires may be substituted for the platinum, they are cheaper, and may easily be removed, when done with, by melting. But the execution of the process is not easy, as it is very difficult to ascertain that the skeleton anode is nowhere in contact with the enclosing mould; to avoid such contact, wrap all the external parts of the platinum anode with a spiral of rubber thread. As the increase of the deposit of copper reduces the distance between the mould and the anode, the latter and the deposit may come in contact, and stop the operation without any exterior sign to attract attention. Thus, if in a trough holding many moulds, one point of contact were established between the two poles, mould and skeleton, all the electricity of the battery would escape at that place, and the working of the bath would stop entirely. To obviate this inconvenience, support all the moulds of the same bath by hooks suspended from a metallic rod. These hooks must have no contact with the metallised surfaces of the moulds, which must be connected with the negative pole by metallic wires terminated above the liquid by very fine iron wires. The connecting wires of the skeleton anode are to pass through the same opening as the negative electrodes, but without contact, and are united to the positive pole. So long as there is no contact between the skeleton and the interior of the mould, the electric fluid finds sufficient passage through the several fine iron wires which connect the moulds with the battery; but, if any contact takes place, the whole of the electricity rushes to that point, and, being too abundant for the small iron wire, it heats and burns it out rapidly. The work is thus instantaneously stopped for this mould, and continues for the others; and the broken wire shows where the defect is. The iron wire should be very short, so as to burn rapidly. In closed moulds and with an insoluble platinum anode, the solution of copper sulphate will be rapidly transformed into sulphuric acid and water. Therefore make two holes at the lower part of the mould, through which and the opening at the head left for the passage of the electrode a free circulation of the liquor in the bath may take place. When the operation is completed, remove the gutta-percha mould, and the skeleton anode must be pulled out. Close the three holes in the statue, and file off the seams left at the junction of the different parts of the mould.

Filling the Hollow Deposit with Brass Solder.—First cover the exterior with clay, plaster of Paris, or Spanish white mixed with charcoal dust, and dry in a stove-room. This coat is to prevent the copper deposit from losing its shape and being oxidised by the heat. The interior of the article is then to be filled with the softest brass solder and powdered borax, which are melted by a gas or turpentine blowpipe. All the hollow parts are soon filled with the solder, which imparts to them as much firmness and durability as is to be found in cast articles.

Removing the Mould.—With a metallic mould, after having removed the useless portions of the deposits, pass a card or a blade of ivory between the model and the deposit. The operation is the same with moulds of plaster of Paris, porcelain, marble, glass, or wood; but it is difficult to save a plaster mould which has been in the bath, and which is nearly always sacrificed. Moulds of wax, stearine, fusible metal, gelatine, or gutta-percha are softened in boiling water, and their separation presents no difficulty whatever.

Finishing up the Articles.—The articles when separated from the moulds are generally spotted with plumbago, grease, or other substances from the moulds. It is usual to heat them, so as to burn out the impurities, and to cleanse them by immersion in a pickle of dilute sulphuric acid. The heating renders the copper deposit softer and more malleable; but it may result in injury to the minute details and the fineness of the copy. Therefore, for delicate works, it is preferable to clean with alcohol, turpentine, or benzole, and to rub the surface with a stiff brush; finish with a paste of Spanish white in water, which let dry upon the object before it is wiped out. Should any Spanish white remain in the hollows, it may be dissolved in water holding one-tenth of its volume of hydrochloric acid, which does not corrode the copper. Complete the operation by rinsing in fresh water, and drying in sawdust or otherwise. When it is desired to anneal the articles without injury to their surface, plunge them into boiling colza or linseed oil, or simply grease, which will bear a heat sufficient for annealing, and will prevent the oxidising action of the air. This annealing in fatty substances is to be recommended in the case of highly undercut moulds of gutta-percha, which may have left part of their substance in the deep recesses of the copy. The gutta-percha is first softened, and then dissolved in the fatty material.

GALVANOPLASTIC OPERATIONS WITH GOLD OR SILVER.—The processes are more difficult and less effective than those for copper. In the case of non-conducting and deeply-wrought moulds, after having deposited by the ordinary process a thin coating of copper, the whole is plunged into the silver bath, which then works very well. After the separation of the copy from the mould, allow it to rest in a solution of ammonia or of very dilute nitric acid, which, after a time dissolves the copper, and leaves the silver deposit. This reproduction must be imperfect, as there is, between the mould and the precious metal, an intermediate layer of copper of unequal thickness. When the surfaces are but slightly in relief, employ moulds of lead, tin, or fusible metal, upon which silver or gold will deposit well and without adherence. Lead is preferable to the other metals, especially when the mould may be obtained by pressure. Cover the pattern with a very thin foil of lead larger than the object, the gutta-percha is applied upon it, and pressed, as before explained. The lead foil, without being torn, will follow all the details of the pattern, and may be separated afterwards with the gutta-percha which it has metallised. Instead of lead, silver or gold foils may be used, and are so thin that the seams disappear by simple pressure. A somewhat thick sheet of very pure lead may be employed for taking moulds of engravings upon copper or steel. The lead and the engraved plate are to be passed between rollers, or simply pressed under a screw press.

Baths for Silver and Gold.—The bath for silver is composed of distilled water, $1\frac{3}{4}$ pint; potassium cyanide, 7 oz.; nitrate of silver, fused, $2\frac{1}{2}$ oz. The gold bath is made of distilled water, 2 pints;

potassium cyanide, 6 oz.; neutral gold chloride, 2 oz. These baths generally work with separate batteries, and with anodes of the metal used in the solution, or the porous cells and zincs may be put into the bath itself, provided that the exciting liquor be a more or less concentrated solution of potassium cyanide. The zincs must not be amalgamated, unless in separate batteries. Green gold is obtained by mixing 10 parts gold bath with 1 of silver bath, or by employing for a time a silver anode in the gold solution. The deposits of gold and silver, after their separation from the mould, should be heated and scratch-brushed; and a proper shade may be given to them by a short sojourn in ordinary electro-gilding or silvering baths.

POLISHING.

POLISHING MATERIALS.—*Crocus.*—Put tin, as pure as possible, into a glass vessel—a wineglass does very well when making small quantities—and pour in sufficient nitric acid to cover it. Great heat is evolved, and care must be taken not to inhale the fumes, as they are poisonous. When there is nothing left but a white powder, it should be heated in a Hessian crucible, to drive off the nitric acid.

Plate Powders.—(*a*) Take equal parts of precipitated subcarbonate of iron and prepared chalk. (*b*) An impalpable rouge may be prepared by calcining iron oxalate. (*c*) Take quicksilver with chalk, ½ oz., and prepared chalk 2 oz., mix them. When used, add a small quantity of spirit of wine, and rub with chamois leather. (*d*) Put iron sulphate into a large tobacco pipe, and place it in a fire for ¼ hour; mix with a small quantity of powdered chalk. This powder should be used dry.

Putty Powder or Oxide of Tin.—Metallic tin is dissolved in nitro-muriatic acid, and precipitated from the filtered solution by liquid ammonia, both fluids being largely diluted with water. The tin peroxide is then washed in abundance of water. Collect in a cloth filter, and squeeze as dry as possible in a piece of new linen. The mass is now subjected to pressure in a screw press, or between two lever boards, to make it as dry as possible. When the lump thus produced has been broken, it is placed in a crucible, and closely covered up to prevent jets from entering, and is then exposed and heated to a white heat, and ground for use in the usual way; this oxide is used specially for cements, and polishing astronomical object-glasses for astro-telescopes. The putty powder of commerce, if of good fair quality, is alloyed with about equal parts of tin and lead, which answers for ordinary purposes, but not for polishing lenses, in which good work is wholly dependent on the quality of the powder.

Razor Paste.—(*a*) Mix fine emery intimately with fat and wax until the proper consistency is obtained in the paste, and then rub it well into the leather strap. Prepare the emery by pounding thoroughly in a mortar the coarse kind, throwing it into a large jug of water, and stirring well. Immediately the large particles have sunk, pour off into a shallow plate or basin, and let the water evaporate. This emery is better for engraving and other purposes than that prepared at the emery mills.

(*b*) The grit from a fine grindstone is very efficient for a razor paste.

(*c*) Levigated oxide of tin (prepared putty powder), 1 oz.; powdered oxalic acid, ¼ oz.; powdered gum, 20 gr.; make into a stiff paste with water, and evenly and thinly spread it over the strop. With very little friction, this paste gives a fine edge to the razor, and its efficiency is still further increased by moistening it.

(*d*) Emery reduced to an impalpable powder, 2 parts; spermaceti ointment, 1 part; mix together, and rub it over the strop.

(*e*) Jewellers' rouge, black-lead, and suet, equal parts; mix.

Rouge.—The rouge used by machinists, watchmakers, and jewellers is a mineral substance. In its preparation crystals of iron sulphate, commonly known as copperas, are heated in iron pots, by which the sulphuric acid is expelled and the oxide of iron remains. Those portions least calcined, when ground, are used for polishing gold and silver. These are of a bright crimson colour. The darker and more calcined portions are known as crocus, and are used for polishing brass and steel. For the finishing process for the specula of telescopes, usually made of iron or of steel, crocus is invaluable: it gives a splendid polish. Others prefer for the production of rouge the peroxide of iron precipitated by ammonia from a dilute solution of iron sulphate, which is washed, compressed until dry, then exposed to a low red heat and ground to powder.

Jewellers' Rouge.—A rouge suitable for fine work may be made by decomposing a solution of iron sulphate with oxalic acid also in solution; a precipitate of iron oxalate falls, which must be well washed and dried; when gently heated, the salt takes fire, leaving an impalpable powder of iron oxide.

POLISHING WHEELS.—*Emery Wheels.*—(*a*) Can be made with shellac powdered fine, and a small portion of rosin, a piece about the size of a walnut to 1 oz. shellac, and a piece of old vulcanised rubber about the same size, which gives it toughness. Shellac about 1 oz. to 1 lb. of emery, well melt, and stir about in a small frying pan; well mix the powders before applying heat. Be careful not to burn it, or get grease in it; have a ring of iron and a piece of plate iron prepared with black-lead and beer pretty thick; place the ring upon the plate and make a mould, turn the stuff into it, and well ram down evenly; put on one side to cool; when cold, turn out and chuck in lathe, and with a piece of red-hot iron bore a hole for spindle; after spindled put between centres, and trice-up with hot iron. Very good grindstones may be made with silver-sand mixed with powdered glass, and it is necessary to have some body besides shellac for coarse emery to form a body to bed the grains in. Emery dust from grinding glass, and Turkey-stone slips, and slate, may be used as a substitute for the flour.

(*b*) The best emery wheels are formed of clean emery compounded with just a sufficient amount of boiled linseed oil, the mixture being agitated for a sufficient period under exposure to a considerable temperature and a free access of atmospheric air, or some still more powerful oxidising agent; it assumes the necessary degree of tenacity, and whilst warm, being exposed to hydraulic pressure in a suitable mould, and subsequent drying in a stove, the emery wheel is complete.

Glaze Wheels for Finishing Steel.—For hollow finishing the following wheels are required:—A mahogany wheel for rough glazing. A mahogany wheel for smooth glazing. A lead wheel, or lap. For flat finishing: A buff wheel for rough. A buff wheel for smooth. A buff wheel for finishing. Lastly, a polisher. To make the glaze wheels: Get the spindles, and point them on each end; then get a block of beech and wedge it on the steel at one end with iron wedges, and turn it for the pulley for the band to run on. Take two pieces of flat mahogany and glue and screw them together, so that the grain of one piece crosses the other, to prevent warping. Let it get thoroughly dry, and wedge it on the spindle and turn it true. The lead wheel is made the same way, but made wider, and a groove is turned in the edge. Then the wheel is put into sand, and a ring of lead is run round the edge; it is then turned true. To make the buff wheels, proceed as with the glaze; but to save expense, pine or deal wood will do as well as mahogany, only leave it about double the width of the glaze, which is about ½ in. wide, by 12–14 in. across. The buff wheels are covered with glue, and then the leather is tacked on with tacks driven in about half-way, so that they may be easily drawn out again. The leather is then turned true. The polisher is made the same way, but the size of the polisher must be a little less than any of the other wheels, say, about an inch. The buff wheels are dressed by laying on a fine thin coat of clear glue, and rolling them round—No. 1, in superfine corn emery; No. 2, in smooth emery; No. 3, by making a cake of equal parts of mutton suet, beeswax, and washed emery; then it is held on the wheel while it is going round. The glaze wheels are dressed while using, by mixing a little of the emery with oil, and putting it on the wheel with a stick or the finger. The leather of the polisher is not covered with glue, but dressed with a mixture of crocus and water, not oil. Care must be taken to keep each wheel and substance to themselves, and the work must be carefully wiped after each operation; cleanliness must be studied above all things in using the polisher, as the slightest grease getting on it stops the polishing.

Grindstone, Artificial.—Washed silicious sand 3 parts, shellac 1 part; melt the lac, and mould in the sand, while warm. Emery may be substituted for sand. Used for razors and fine cutlery.

Burnishing.—To burnish an article is to polish it, by removing the small roughness upon its surface; and this is performed by a burnisher. This mode of polishing is the most expeditious, and gives the greatest lustre to a polished body. It removes the marks left by the emery, putty, or other polishing materials; and gives to the burnished articles a black lustre, resembling that of looking-glass. The form and construction of the burnisher is extremely variable, according to the respective trades; and it must be adapted to the various kinds of work in the same art. In general, this tool is only intended to efface inequalities. Whatever substance the burnisher is made of is of little consequence to the article burnished, provided only that it is of a harder substance than that article.

Burnishers.—The burnishers used are of two kinds, of steel and of hard stone. They are either curved or straight, rounded or pointed, and made so as to suit the projecting parts, or the hollows of the piece. Stone burnishers are made of blood-stone, cut, and either rounded with the grindstone, or rubbed, so that they present, at the bottom, a very blunt edge, or sometimes a rounded surface. These are polished with emery, like steel burnishers, and are finished by being rubbed upon a leather, covered with crocus martis. The stone is mounted in a wooden handle, and firmly fixed by a copper ferrule, which encircles both the stone and the wood. The best blood-stones are those which contain the most iron, and which, when polished, present a steel colour. The operation of burnishing is very simple; take hold of the tool very near to the stone, and lean very hard with it on those parts which are to be burnished, causing it to glide by a backward and forward movement, without taking it off the piece. When it is requisite that the hand should pass over a large surface at once, without losing its point of support on the work-bench, in taking hold of the burnisher be careful to place it just underneath the little finger. By this means the work is done quicker, and the tool is more solidly fixed in the hand. During the whole process, the tool must be continually moistened with black soapsuds. The water with which it is frequently wetted causes it to glide more easily over the work, prevents it from heating, and facilitates its action. The black soap, containing more alkali than the common soap, acts with greater strength in cleansing off any greasiness which might still remain on the surface; it also more readily detaches the spots which would spoil the beauty of the burnishing. In consequence of the friction the burnisher soon loses its bite, and slips over the surface of the article as if it were oily. In order to restore its action, it must be rubbed, from time to time, on the leather. The leather is fixed on a piece of hard wood, with shallow furrows along it. There are generally two leathers—one made of sole leather and the other of buff leather. The first is impregnated with a little oil and crocus martis, and is particularly used for the blood-stone burnishers; the other has only a little putty of tin scattered in the furrows, and is intended exclusively for rubbing steel burnishers, as they are not so hard as the blood-stones. Blood-stone being very hard, the workman uses it whenever he can, in preference to the steel burnisher. It is only in small articles, and in difficult places, that steel burnishers are used, as they, by their variety of form, are adapted to all kinds of work. In general, the blood-stone greatly reduces the labour. When the articles, on account of their minuteness or from any other cause, cannot be conveniently held in the hand, they are fixed in a convenient frame on the bench; but under all circumstances be very careful to manage the burnisher so as to leave untouched those parts of the work which are intended to remain dull. When, in burnishing an article which is plated or lined with silver, there is any place where the layer of precious metal is removed, restore it by silvering these places with a composition supplied by the silverer, which is applied with a brush, rubbing the part well, and wiping it afterwards with an old linen cloth. The burnishing being finished, remove the soapsuds which still adhere to the surface of the work; this is effected by rubbing it with a piece of old linen cloth. But when there are a great number of small pieces to finish, to throw them into soapsuds and dry them afterwards with saw-dust is more expeditious.

The burnishing of gold leaf or silver, on wood, is performed with burnishers made of dogs' teeth, or agates, mounted in iron or wooden handles. When about to burnish gold, applied on other metals, dip the blood-stone burnisher into vinegar; this kind being exclusively used for that purpose. But when burnishing leaf-gold on prepared surfaces of wood, keep the stone, or tooth, perfectly dry.

The burnisher used by leather gilders is a hard polished stone, mounted in a wooden handle — this is to sleek or smooth the leather.

The ordinary engravers' burnisher is a blade of steel, made thin at one end, to fit into a small handle to hold it by. The part in the middle of the blade is rounded on the convex side, and is also a little curved. The rounded part must be well polished, and the tool be very hard. This burnisher is used to give the last polish to such parts of copper and steel plates as may have been accidentally scratched, or specked, where false lines are to be removed, and also to lighten in a small degree such parts as have been too deeply etched or graved.

In clockmaking, those pieces or parts are burnished which, on account of their size or form, cannot be conveniently polished. The burnishers are of various forms and sizes; they are all made of cast steel, very hard, and well polished; some are formed like sage-leaf files, others like common files—the first are used to burnish screws, and pieces of brass; the others are used for flat pieces. The clockmakers have also very small ones of this kind, to burnish their pivots—they are called pivot burnishers.

Burnishing Cutlery.—The burnishing of cutlery is executed by hand or vice burnishers; they are all made of fine steel, hardened, and well polished. The first kind have nothing particular in their construction; but vice burnishers are formed and mounted in a very different manner. On a long piece of wood, placed horizontally in the vice, is fixed another piece, as long, but bent in the form of a bow, the concavity of which is turned downwards. These two pieces are united at one of their extremities by a pin and a hook, which allows the upper piece to move freely around this point as a centre. The burnisher is fixed in the middle of this bent piece, and it is made more or less projecting, by the greater or lesser length which is given to its base. The movable piece of wood, at the extremity opposite to the hook, is furnished with a handle, which serves the workman as a lever. This position allows the burnisher to rest with greater force against the article to be burnished, which is placed on the fixed piece of wood. The burnisher has either the form of the face of a roundheaded hammer, well polished, to burnish those pieces which are plain or convex; or the form of two cones opposed at their summits, with their bases rounded, to burnish those pieces which are concave or ring-shaped.

Burnishing Pewter.—The burnishing of pewter articles is done after the work has been turned, or finished off with a scraper—the burnishers are of different kinds, for burnishing articles either by hand, or in the lathe; they are all of steel, and while in use are rubbed with putty powder on leather, and moistened with soapsuds.

Burnishing Silver. — Commence by cleaning off any kind of dirt which the surfaces of the silver articles had contracted whilst making, as that would entirely spoil the burnishing. For this purpose take pumice powder, and with a brush, made very wet in strong soapsuds, rub the various parts of the work, even those parts which are to remain dull, which, nevertheless, receive thus a beautiful white appearance; wipe with an old linen cloth, and proceed to the burnishing.

French Polishing.—As in varnishing, a warm, dry atmosphere is essential, and all draughts of cold air from door or window must be avoided.

Pour a little linseed oil into a cup and some polish into another; take a piece of woollen rag a few inches square, and having rolled it up into a ball saturate it with polish, and cover with a piece of linen or muslin drawn tightly over it. In this way the rubbers or pads are prepared, and they should, when taken by the fingers of the right hand, be held in such a manner as to draw the linen covering tight, and present a smooth, slightly convex surface to work with; apply one drop of oil and one drop of polish to the surface of the pad, and it is ready for use. Care must be taken that the material of which the rubbers are made is well washed and free from starch or soap. The work having been thoroughly smoothed with fine glass paper and the dust wiped away with a clean cloth, the polishing is commenced with free, continuous and uniform circular strokes, applied with very slight pressure, and gradually traversing the whole surface, observing not to do more than a square foot at a time; the same process is repeatedly continued, varying the position of the strokes as much as possible, but keeping them about the same size, and taking care that every portion of the surface receives an equal but not excessive quantity of polish, which is regulated partly by the degree of pressure on the rubber, and partly by squeezing it between the fingers.

The process of polishing is continued until the grain of the wood appears to be thoroughly filled up, and the surface exhibits a uniform appearance, well covered with a thin coat of polish. It is then allowed to stand for an hour or two to become thoroughly hard, when it is rubbed with very fine glass paper, to smooth down all the irregularities of the grain of the wood, and also of the polish. The polishing is then repeated, and, if it should be found necessary, it is again smoothed, and the polishing is persevered in until the surface appears quite smooth, and uniformly covered with a thin and tolerably bright coat of polish, but which will, nevertheless, show cloudy marks from the rubber, owing to the presence of the oil, which is finally removed with a few drops of spirits of wine applied on a clean rubber and covered with a clean soft linen rag, with which the work is rubbed with very light strokes, applied first with a circular motion, and when the surface appears nearly dry, straight strokes are taken lengthways of the grain of the wood, and traversed entirely off the ends of the work; this is continued until the rubber and work are both quite dry, when the polishing will be completed. The polish, however, will be partly absorbed by the wood in the course of a day or two; and therefore it is desirable to repeat the process after a lapse of a few days, first slightly rubbing down the former coat with very fine or nearly worn-out glass paper.

Stopping for French Polishing.—Plaster of Paris, when made into a creamy paste with water, proves a most valuable pore-filling material. It is to be rubbed by means of a coarse rag across the woody fibre into the holes and pores, till they are completely saturated, and then the superfluous stucco on the outside is to be instantly wiped off. The succeeding processes are technically termed papering, oiling, and embodying.

When finely-pounded whiting is slaked with painters' drying oil, it constitutes another good pore-filler. It is applied in the same manner as the preceding, and it is recommended on account of its quickly hardening and tenacious virtues as a cement; sometimes white-lead is used in lieu of the whiting.

Before using either of these, or other compositions for the same purpose, it is best to tint them to correspond exactly with the colour of the article it is intended to size.

Holes and crevices may be well filled up with a cement that is made by melting beeswax in combination with rosin and shellac.

French Polishes.—(*a*) 1 pint spirits of wine, ¼ oz. gum copal, ¼ oz. gum arabic, and 1 oz. shellac. Bruise the gums and sift them through a piece of muslin. Place the spirits and the gums together in a vessel closely corked, near a warm stove, and frequently shake them; in two or three days they will be dissolved. Strain through a piece of muslin, and keep corked tight.

(*b*) Dissolve 1½ oz. shellac, ¼ oz. sandarach, in ½ pint naphtha. To apply the polish, fold a piece of flannel into a sort of cushion, wet it well with the polish, then lay a piece of clean linen rag over the flannel, apply one drop of linseed oil; rub your work in a circular direction lightly at first. To finish off, use a little naphtha applied the same as the polish.

(*c*) Pale shellac, 2¼ lb.; mastic and sandarach, each 3 oz.; spirits, 1 gal. Dissolve, and add copal varnish, 1 pint; mix well by agitation.

(*d*) Shellac, 12 oz.; wood naphtha, 1 qt.; dissolve, and add ½ pint linseed oil.

(*e*) Crush 3 oz. shellac with ½ oz. gum mastic, add 1 pint methylated spirits of wine, and dissolve.

(*f*) Shellac, 12 oz.; gum elemi, 2 oz.; gum copal, 3 oz.; spirits of wine, 1 gal.; dissolve.

(*g*) Shellac, 1½ oz.; gum juniper, ½ oz.; benzoin, ½ oz.; methylated alcohol, ½ pint.

(*h*) 1 oz. each of gums mastic, sandarach, seed-lac, shellac, and gum arabic; reduce to powder; then add ¼ oz. virgin wax; dissolve in a bottle with 1 qt. rectified spirits of wine. Let it stand for 12 hours, and it is then fit for use.

(*i*) 1 oz. gum-lac; 2 dr. mastic in drops; 4 dr. sandarach; 3 oz. shellac; ½ oz. gum dragon. Reduce the whole to powder.

French Polish Reviver.—(*a*) Linseed oil, ½ pint; spirits of camphor, 1 oz.; vinegar, 2 oz.; butter of antimony, ½ oz.; spirit of hartshorn, ¼ oz.

(*b*) ½ gill vinegar; 1 gill spirits of wine; 1 dr. linseed oil.

(*c*) Naphtha, 1 lb.; shellac, 4 oz.; oxalic acid, ¼ oz. Let it stand till dissolved, then add 3 oz. linseed oil.

(*d*) Pale linseed oil, raw, 10 oz.; lac varnish and wood spirit, of each 5 oz. Mix well before using.

Furniture Pastes.—(*a*) To keep wood light, scrape ¼ lb. beeswax into ½ pint turpentine. By adding linseed oil the wood is darkened.

(*b*) Dissolve 6 oz. pearlash in 1 qt. hot water, add ¼ lb. white wax, and simmer for ½ hour in a pipkin; take from off the fire; when cool, the wax will float; it should be taken off, and, with a little hot water, worked into a paste.

(*c*) Beeswax, spirits of turpentine, and linseed oil, equal parts; melt and cool.

(*d*) Beeswax, 4 oz.; turpentine, 10 oz.; alkanet root to colour, melt and strain.

(*e*) Digest 2 dr. alkanet root in 20 oz. turpentine till the colour is imparted; add yellow wax in shavings, 4 oz., place on a water bath and stir till the mixture is complete.

(*f*) Beeswax, 1 lb.; linseed oil, 5 oz.; alkanet root, ½ oz.; melt, add 5 oz. turpentine, strain and cool.

(*g*) Beeswax, 4 oz.; rosin, 1 oz.; oil

of turpentine, 2 oz.; Venetian red to colour.

(*h*) 1 lb. white wax; 1 oz. black rosin; 1 oz. alkanet root; and 10 oz. linseed oil.

Furniture Creams.—(*a*) Yellow wax, 4 oz.; yellow soap, 2 oz.; water, 50 oz.; boil, with constant stirring, and add boiled oil and oil of turpentine, each 5 oz.

(*b*) Soft water, 1 gal.; soap, 4 oz.; white wax, in shavings, 1 lb. Boil together, and add 2 oz. pearlash. To be diluted with water, laid on with a paint brush, and polished off with a hard brush or cloth.

(*c*) Wax, 3 oz.; pearlash, 2 oz.; water, 6 oz. Heat together, and add 4 oz. boiled oil and 5 oz. spirits of turpentine.

(*d*) Raw linseed oil, 6 oz.; white wine vinegar, 3 oz.; methylated spirit, 3 oz.; butter of antimony, ½ oz.; mix the linseed oil with the vinegar by degrees, and shake well so as to prevent separation; add the spirit and antimony, and mix thoroughly.

Furniture Oils.—(*a*) Boiled linseed oil, 1 pint; yellow wax, 4 oz.; melt, and colour with alkanet root.

(*b*) Acetic acid, 2 dr.; oil of lavender, ½ dr.; rectified spirit, 1 dr.; linseed oil, 4 oz.

(*c*) Linseed oil, 1 pint; alkanet root, 2 oz.; heat, strain, and add lac varnish, 1 oz.

(*d*) Linseed oil, 1 pint; rectified spirit, 2 oz.; butter of antimony, 4 oz.

(*e*) For darkening furniture, 1 pint linseed oil; 1 oz. rose-pink; and 1 oz. alkanet root, beaten up in a metal mortar; let the mixture stand for a day or two; then pour off the oil, which will be found of a rich colour.

(*f*) Mix 2 oz. alkanet root with 4 oz. shellac varnish, 2 oz. turpentine, the same quantity of scraped beeswax, and 1 pint linseed oil; this should stand a week.

For Turners' Work.—Dissolve 1 oz. sandarach in ½ pint spirits of wine; shave 1 oz. beeswax, and dissolve it in a sufficient quantity of spirits of turpentine to make it into a paste; add the former mixture to it by degrees; then, with a woollen cloth, apply it to the work while it is in motion in the lathe, and polish it with a soft linen rag; it will appear as if highly varnished.

For Wainscot.—Take as much beeswax as required, and placing it in a glazed earthen pan, add as much spirits of wine as will cover it, and let it dissolve without heat. Add either one ingredient as is required, to reduce it to the consistence of butter. When this mixture is well rubbed into the grain of the wood, and cleaned off with clean linen, it gives a good gloss to the work.

For Carved Cabinet-work.— Dissolve 2 oz. seed-lac, and 2 oz. white rosin, in 1 pint spirits of wine. This varnish or polish must be laid on warm, and if the work can be warmed also, it will be so much the better; at any rate, moisture and dampness must be avoided. Used with a brush for standards or pillars of cabinet-work. The carved parts of cabinet-work are also polished thus: varnish the parts with common wood varnish, and having dressed them off where necessary with emery paper, apply the polish used for the other parts of the work.

Copal Polish. — Melt with gentle heat finely-powdered gum copal, 4 parts, and gum camphor, 1 part, with ether to form a semi-fluid mass, and then digest with a sufficient quantity of alcohol.

For Wood Carving. — Take a piece of wadding, soft and pliable, and drop a few drops of white or transparent polish or French, polish, according to the colour of the wood. Wrap the wetted wadding up in a piece of old linen, forming it into a pad; hold the pad by the surplus linen; touch the pad with one or two drops of linseed oil. Pass the pad gently over the parts to be polished, working it round in small circles, occasionally re-wetting the wadding in polish, and the pad with a drop or so of oil. The object of the oil is merely to cause the pad to run over the wood easily without sticking, therefore as little as possible should be used, as it tends to deaden the polish to a certain extent. Where a carving is to be polished after having been varnished, the same process is necessary, but it can only be applied to the plainer portions of the work. Plane surfaces must be made perfectly smooth with glass paper before polishing, as every scratch or mark will show twice as badly after the operation. When the polish is first rubbed on the wood, it is called the *bodying in;* it will sink into the wood and not give much glaze. It must, when dry, have another body rubbed on, and a third generally finishes it; but if not, the operation must be repeated. Just before the task is completed, greasy smears will show themselves; these will disappear by continuing the gentle rubbing without oiling the pad.

Fretwork.—The wood is first well smoothed with fine glass paper, then covered with a thin coating of size, made from transparent glue, to prevent the varnish from sinking into the wood. When dry, pour some varnish into a saucer; take a fine camel-hair brush, and commence to varnish at one corner, gradually spreading over the whole surface. Take care that there is not too much varnish on the brush, or an even surface cannot be obtained. The first coating must be allowed to dry, which will take two or three hours. Take a sheet of the finest glass paper, and when the first coating of varnish is perfectly dry, glass-paper the whole surface, and make it smooth as before. This done, with great care spread next coat of varnish on, always using the glass paper when the surface does not turn out very smooth. The whole, when dry, may be rubbed well with a piece of worn woollen till it is bright and smooth. To French polish the work, make the wood smooth as before. Then pour some prepared polish into a saucer, and some linseed oil into another. Then take some pieces of woollen rag, and roll them up into a ball, covering them with a piece of linen drawn tightly over. The rags inside should first be saturated with the polish, and the whole should be taken in the fingers of the right hand in such a way that the linen may be tightly drawn over, and may present to the wood a smooth rounded surface. Begin by polishing with free, circular strokes, and gradually traversing the whole surface. Apply now and then a drop of polish and a drop of oil to the surface of the rubber. When the grain of the wood disappears, allow it to stand for an hour or two till quite hard, and then glass-paper the whole as in varnishing. Repeat the process of polishing until the surface is quite smooth. If dull patches appear in the polish, they may be removed by a few drops of spirits of wine on a new rubber.

Horn and Ivory.—Ivory and bone admit of being turned very smooth, or when filed may afterwards be scraped so as to present a good surface. They may be polished by rubbing first with fine glass-paper, and then with a piece of wet linen cloth dipped in powdered pumice. This will give a very fine surface, and the final polish may be produced by washed chalk or fine whiting applied by a piece of cloth wetted with soapsuds. Care must be taken in this, and in every instance where articles of different fineness are used, that, previous to applying a finer, every particle of the coarser material is removed, and that the rags are clean and free from grit. Ornamental work must be polished with the same materials as plain work, using brushes instead of linen, and rubbing as little as possible, otherwise the more prominent parts will be injured. The polishing material should be washed off with clean water, and when dry, may be rubbed with a clean brush.

Horn and tortoiseshell are so similar in their nature and texture that they may be classed together. As regards the general mode of working and polishing them, a very perfect surface is given by scraping. The scraper may be made of a razor-blade, the edge of which should be rubbed upon an oil-stone, holding the blade nearly upright, so as to form an edge like that of a currier's knife, which may be sharpened by burnishing. Work when properly scraped is prepared for polishing. To effect this it is first rubbed with a buff made of woollen cloth perfectly free from grease. The cloth may be fixed upon a stick to be used by hand; but a "bob," which is a wheel running in the lathe and covered with the cloth, is much to be preferred on account of the rapidity of motion. The buff may be covered either with powdered charcoal and water, or fine brick-dust and water. After the work has been made as smooth as possible with this, it is followed by another bob on which washed chalk or dry whiting is rubbed. The article to be polished is slightly moistened with vinegar, and the buff and whiting will produce a fine gloss, which may be completed by rubbing with the palm of the hand and a small portion of dry whiting or rotten-stone.

(*a*) Well scrape with glass or steel scraper, afterwards with finest glass-cloth, then with powdered bath brick and oil, and finally with rotten-stone and flannel, or old cloth or felt hat.

(*b*) First scrape with glass to take off any roughness, then grind some pumice to powder, and with a piece of cloth wetted and dipped in the powder, rub them until a smooth face is obtained. Next polish with rotten-stone and linseed oil, and finish with dry flour and a piece of clean linen rag. The more rubbing with the stone and oil, the better the polish. Trent sand is used in the Sheffield factories. It is a very fine and sharp sand, and is prepared for use by calcining and sifting.

Polishing in the Lathe.—Good work does not require much polishing, for the beauty of it depends more on being executed with tools properly ground, set, and in good order; the work performed by such tools will have its surface much smoother, its mouldings and edges much better finished, and the whole nearly polished, requiring, of course, much less subsequent polishing than work turned with blunt tools. One of the most necessary things in polishing is cleanliness; therefore, previous to beginning, it is as well to clear the turning-lathe or work-bench of all shavings, dust, and so on, as also to examine all the powders, lacquers, linen, flannel, or brushes which may be required; to see that they are free from dust, grit, or any foreign matter. For further security, the polishing powders used are sometimes tied up in a piece of linen, and shaken as through a sieve, so that none but the finest particles can pass. Although, throughout the following methods, certain polishing powders are recommended for particular kinds of work, there are others applicable to the same purposes, the selection from which remains with the operator; observing this distinction, that when the work is rough and requires much polishing, the coarser powders are best; but the smoother the work, the less polishing it requires, and the finer powders are preferable.

Soft woods may be turned so smooth as to require no other polishing than that produced by holding against it a few fine turnings or shavings of the same wood whilst revolving, this being often sufficient to give it a finished appearance; but when the surface of the wood has been left rough, it must be rubbed smooth with polishing paper, constantly varying the position of the hand, otherwise it would occasion rings or grooves in the work. When the work has been polished with the lathe revolving in the usual way, it appears to be smooth; but the roughness is only laid down in one direction, and is not entirely removed, which would prove to be the case by turning the lathe the contrary way, and applying the glass paper; on which account work is polished best in a pole-lathe, which turns backwards and forwards alternately, and therefore it is well to imitate that motion as nearly as possible.

Mahogany, *walnut*, and some other woods, of about the same degree of hardness, may be polished by either of the following methods:—Dissolve, by heat, so much beeswax, in spirits of turpentine, that the mixture when cold shall be of about the thickness of honey. This may be applied either to furniture or to work running in the lathe, by means of a piece of clean cloth, and as much as possible should then be rubbed off by means of a clean flannel or other cloth. Beeswax alone is often used; upon furniture it must be melted by means of a warm flat iron; but it may be applied to work in the lathe by holding the wax against it until a portion of it adheres; a piece of woollen cloth should then be held upon it, and the lathe turned very quickly, so as to melt the wax, the superfluous portion of which may be removed by means of a small piece of wood or blunt metal, when a light touch with a clean part of the cloth will give it a gloss. A very good polish may be given to mahogany by rubbing it over with linseed oil, and then holding against it a cloth dipped in fine brick-dust. Formerly nearly all the mahogany furniture made in England was polished in this way.

Hard Woods.—These, from their nature, are readily turned very smooth; fine glass paper will suffice to give them a very perfect surface; a little linseed oil may then be rubbed on, and a portion of the turnings of the wood to be polished may then be held against the article, whilst it turns rapidly round, which will, in general, give it a fine gloss. Sometimes a portion of seed-lac varnish is applied upon a piece of cloth, in the way formerly described. The polish of all ornamental work wholly depends on the execution of the same, which should be done with tools properly sharpened; and then the work requires no other polishing but with a dry hand-brush, to clean it from shavings or dust, this trifling friction being sufficient to give the required lustre.

Metals.—The polishing of metals differs according to their kind, but there are some general principles common to all, of which it may be useful to have a clear idea. All polishing is begun in the first instance by rubbing down the surface by some hard substance that will produce a number of scratches in all directions, the level of which is nearly the same, and which obliterate the marks of the file, scraper, or turning tool that has been first employed. For this purpose coarse emery is used, or pumice and water, or sand and water, applied upon a piece of soft wood, or of felt, skin, or similar material. When the first coarse marks have been thus removed, next proceed to remove the marks left by the pumice by finely-powdered pumice ground up with olive oil, or by finer emery and oil. In some cases certain polishing stones are employed, as a kind of hard slate used with water. To proceed with the polishing, still finer powders are used, such as tripoli and rotten-stone. Putty of tin and crocus martis are also used for high degrees of polish. But the whole process consists merely in removing coarse scratches by substituting those which are finer and finer, until they are no longer visible to the naked eye; and even long after that, if the surface is examined by a microscope, it will be seen that what appeared without any scratches is covered all over with an infinity of them, but so minute that they require a high magnifier to be discovered. It is evident that great care must be taken to have the last polishing material uniformly fine, for a single grain or two of any coarse substance mixed with it will produce some visible scratches instead of a perfectly polished surface.

Brass.—(*a*) Brass may be polished without a burnisher, by using an exceedingly fine cut file, and fine emery cloth.

(*b*) Small articles to be polished should be shaken by themselves for a short time; then some greasy parings of leather should be put in the band with them. After they have been shaken smooth, the greasy leather parings should be removed and clean ones put in, and the shaking continued until the articles are sufficiently bright.

(*c*) When the brass is made smooth by turning or filing with a very fine file, it may be rubbed with a smooth fine-grained stone, or with charcoal and water. When it is made quite smooth and free from scratches, it may be polished with rotten-stone and oil, alcohol, or spirits of turpentine.

German Silver.—Take 1 lb. iron peroxide, pure, and put half of it into a wash-basin, pouring on water, and keeping it stirred until the basin is nearly full. While the water and crocus is in slow motion, pour off, leaving grit at the bottom. Repeat this a second time, pouring off with another basin. Cleanse out grit, and do the same with the other half. When the second lot is poured off, the crocus in the first will have settled to the bottom; pour off the water gently, take out the powder, and dry it, and put both when washed clear of grit, and dried, into a box into which dust cannot get. If the work is very dirty, rub the mixture of powder and oil on with the fingers, and then it will be known if any grit is on the work. If the work is not very black, take a piece of soft chamois leather, and rub some dry crocus on, and when well rubbed, shake out the leather, and let the powder fall off that is not used, or rub it off with a brush. Do not put down the leather in the dust.

Iron and Steel.—(*a*) Take an ordinary bar of malleable iron in its usual merchantable state, remove the oxide from its surface by the application of diluted sulphuric acid, after which wash the bar in an alkaline solution, then cover the entire bar with oil or petroleum. The bar is then ready for the chief process. A muffle furnace is so prepared that a uniform, or nearly uniform, heat can be maintained within it, and in this furnace the bar is placed. Care must be taken that too great a heat is not imparted to it, for on this depends the success of the operation. When the bar approaches a red heat, and when the redness is just perceptible, it is a certain indication that the proper degree of heat has been attained. The bar is then at once to be removed, and passed through the finishing rolls five or six times, when it will be found to have a dark polished uniform surface, and the appearance of Russian sheet iron.

(*b*) A good polish for iron or steel rotating in the lathe, is made of fine emery and oil; which is applied by lead or wood grinders, screwed together. Three very good oils for lubrication are olive oil, sperm, and neat's foot.

(*c*) Use bell-metal polishers for arbors, having first brought up the surface with oilstone dust and oil and soft steel polishers; for flat pieces use a piece of glass for the oil-stone dust, and a bell-metal block for the sharp red stuff, and a white metal block for the fine red stuff. The polishing stuff must be well mixed up and kept very clean; the polishers and blocks must be filed to clean off the old stuff, and then rubbed over with soft bread; put only a little red stuff on the block and keep working it until it is quite dry; the piece will then leave the block quite clean; use bread to clean off the surplus red stuff before using the brush. If the piece is scratched, put on some more red stuff, which must not be too wet, and try again.

(*d*) The polish on flat steel pieces in fine watchwork is produced with oilstone dust, burnt Turkey stone, and a steel polisher, soft steel, bell-metal, and sharp stuff, grain tin and glossing stuff. The metals are squared with a file, and vary in shape according to the work in hand.

(*e*) Get an 18-gal. barrel and put an iron spindle through the two ends; mount it on trestles in the same way as a butter churn, with a winch to turn it by; cut out a hole in the side by which to introduce the articles to be polished; have a tight-fitting cover to the hole; procure some worn-out casting pots or crucibles, such as used by casters, and pound them in an iron mortar, until fine enough to pass through a sieve which will not allow the steel articles to pass through. Put equal quantities of this grit and of the articles in the barrel; fasten on the cover, and turn the barrel for about an hour, at the rate of about 50 turns a minute; take all out of the barrel and sift out the grit. If a finer polish than this is required, put them through another turning, substituting for the grit small scraps of leather, called mosings, which can be procured from the curriers, and emery flour. Do not more than half fill the barrel.

Mother-of-Pearl.—Go over it with pumice finely powdered, washed to separate the impurities and dirt, with which polish it very smooth; then apply putty powder and water by a rubber, which will produce a fine gloss and good colour.

Plaster Casts.—(*a*) Put into 4 lb. clear water 1 oz. pure curd soap, grated and dissolved in a well-glazed earthen vessel—then add 1 oz. white beeswax, cut into thin slices; when the whole is incorporated it is fit for use. Having well dried the figure before the fire, suspend it by a twine, and dip it once in the varnish; upon taking it out, the moisture will appear to have been absorbed in 2 minutes' time; stir the compost, and dip the figure a second time; this generally suffices. Cover it carefully from the dust for a week; then, with soft muslin rag, or cotton wool, rub the figure gently, when a most brilliant gloss will be produced.

(*b*) Take skimmed milk, and with a camel-hair pencil lay over the model till it will imbibe no more. Shake or blow off any that remains on the surface, and lay the figure in a place perfectly free from dust; when dry, it will look like polished marble. If the milk is not carefully skimmed it will not answer the purpose.

(*c*) Fuse ½ oz. of tin, with the same quantity of bismuth, in a crucible; when melted, add ½ oz. mercury; when perfectly combined, take the mixture from the fire and cool it. This substance, mixed with the white of an egg, forms a beautiful varnish for plaster of Paris casts.

(*d*) Of stearine and Venetian soap each 2 parts; pearlash, 1; the stearine and soap cut small and mixed with 30 part solution of caustic potash, boiled for ½ hour, stirring continually. Add the pearlash dissolved in a little rain water, and boil a few minutes; stir until cold, and mix with more lye until it is quite liquid; keep well covered up. Remove all dust and stains from the plaster, and apply the wash as long as it is absorbed. When dry, rub with a soft leather or brush. Should the surface not shine, apply another coat. This composition may be preserved for years.

(*e*) Coat with melted white wax, and place them before a fire until the wax is absorbed; a considerable polish can then be obtained by friction.

(*f*) First make very smooth and free from grit with glass-paper or otherwise; oil with linseed oil; when dry, French polish in the usual way. If a bust, or anything similar, required to be white, make smooth, size with white size, and varnish with white hard varnish.

Shells.—(*a*) Marine shells are cleaned by rubbing with a rag dipped in common hydrochloric acid till the outer dull skin is removed, washing in warm water, drying in hot saw-dust, and polishing with chamois leather. Those shells which have no natural polished surface may either be varnished or rubbed with a little tripoli powder and turpentine on wash-leather, then fine tripoli alone, and lastly with a little fine olive oil, bringing up the surface with the chamois as before.

(*b*) The shells are first boiled in a strong solution of potash, then ground on wheels, sometimes through one stratum to show an underlying one, then polished with hydrochloric acid and putty powder. In this operation the hands are in great danger. Shell grinders are generally almost cripples in their hands.

Slate.—Slate is faced first with an iron plate with river sand and water, smoothed with pumice; then japanned and baked to harden the japan, and again smoothed with pumice and polished with rotten-stone.

Vulcanite.—(*a*) Remove scratches with a smooth wet water of Ayr stone, and then polish in the lathe with fine pumice and a stiff brush. After washing the pumice off, polish it with whiting and soft brush.

(*b*) The mathematical instrument makers treat it as brass—that is, for flat work they first use water of Ayr stone, and then rotten-stone and oil. Turned work is polished in the lathe with rotten-stone and oil, taking care not to use too high a speed, which would heat the work. Some use lampblack and oil to finish with where a very high polish is wanted, or the bare palm of the hand, as in getting up silver plate. Chain and ornament makers use circular buffs for their flat work, made of sea-horse-leather, and for work of irregular forms, buffs of calico. A number of pieces, 12 in. in diameter, are screwed together between flanges, like a circular-saw spindle, and used with rotten-stone, always taking care not to heat the work; brushes are not at all suitable for it.

POTTERY.

Bodies.—English porcelain and earthenware are made from the following bodies, which are prepared by soaking the clays in a large vessel of water, and, when of the consistence of slip, passing them through the finest silk lawn into another vessel in which proper gauges are fixed, so that the other materials may be afterwards added in a slop state. Clay slip should weigh 13½ lb.; Cornish clay, 13½ lb.; Cornish stone, 16½ lb.; and flint, 16½ lb. a gallon. The passing through the lawn is repeated as often as is needful, so that the mixture may be deprived of impurities. Care must be taken that the bones used for china bodies are not decayed, and for the other materials used in making porcelain, great care is necessary to see that they are of the purest kinds. These bodies fire at a higher temperature than that usually observed, and are placed and fixed in the furnace with ground flint. For the coloured bodies the marls used should be selected of the finest quality, argillaceous marl being the best; and very fine lawn will be required if it is intended that the body should be clean and free from metallic spots. Clays in which the silicious ingredients are in proportion of three to one are the best for the use of porcelain; those in which argil is in excess are the best for coarser earthenware, because less acted upon by alkalies. The colours in clays produced by vegetables or bituminous particles are destroyed by heat in an open fire, and are by no means prejudicial; but those which arise from metallic particles are obstinate, and should be avoided as much as possible. Clays which contain argil and silex only are very refractory, but calcareous earths in the proportion of 10 to 12 per cent. will render any clay fusible. The clays for porcelain should be those which contain the most sand, and are of the greatest fineness; also such as do not retain water with too much tenacity, which is the case when argil is not combined with fixed air, therefore all clays ought to be exposed to the action of the atmosphere for a long time previous to using. Calcareous earth in its common form is limestone or spar, magnesia, &c., which in their pure state are not so easily dissolved as when combined with fixed air. Argillaceous clay or alumina clay forms the basis of common alum; is called argil, and is never found pure; the finest part is extracted from alum, and is not fusible in the strongest heat required for china or earthenware. Argil in its usual state of dryness is capable of absorbing 2½ times its weight of water. Silicious earths found in a stony state abound in flint; the purest are found in crystals and quartz of a pure white; fixed alkalies, vegetables, or minerals are their true solvents. It should be understood that flint and bones, in all instances, are to undergo the process of calcination previous to using.

Articles formed of one of the bodies are first moderately burned in earthen pots, to receive a certain degree of compactness, and to be ready for glazing. The glaze consists of an easily melted mixture of some species of earths, which, when fused together, produce a crystalline or vitreous mass; this, after cooling, is very finely ground and suspended in a sufficient quantity of water. Into this fluid the rough ware is dipped, by which the glazing matter is deposited uniformly on every part of its surface. After drying, each article is thoroughly baked or fired in the violent heat of the porcelain furnace. It is usual to decorate porcelain by paintings, for which purpose enamels or pastes, coloured by metallic oxides, are used, so easy of fusion as to run in a heat less intense than that in which the glazing of the ware melts.

Black Egyptian.—235 parts blue clay, 225 calcined ochre, 45 manganese, 15 Cornish clay; the materials must be accurately examined on account of the manganese, which ought to be free from lime or other calcareous earth; the pieces of ware when manufactured are very apt to crack, because of the sudden transition from heat to cold, provided above a certain proportion of lime is contained in the manganese. This kind of earthenware requires only once burning, after which it is scoured with fine sand, and then a small quantity of oil is rubbed over it.

Brown.—50 parts red clay, 7½ common clay, 1 manganese, 1 flint.

Calcedony.—32 parts yellow clay, 10 Cornish clay, 4 flint.

Common Brown or Cottage.—20 parts red or brown clay, 8 Cornish clay, 4 blue clay, 2 flint.

Cream Colour.—(*a*) Superior.—1½ part blue clay, 1½ brown clay, 1 black clay, 1 Cornish clay, 1 flint, ¼ Cornish stone.

(*b*) Common.—1½ part blue clay, 1½ brown clay, 1½ black clay, 1 flint.

Drab.—24 parts argillaceous marl, 48 Cornish stone, 24 blue clay, 10 bones, 1 calcined nickel.

Fawn, or Drab.—40 parts marl, 4 Cornish clay, 1 flint.

Fawn, Porous.—40 parts argillaceous clay, 4 blue clay, 2 flint. This body makes porous wine and butter coolers, and water bottles, on the principle of absorption and evaporation. The articles are generally ornamented with various coloured clays; they should be kept in the wet clay state, at the time of being painted, otherwise the different colours laid upon them will not sufficiently adhere, but are liable to chip and peel off when burned. A moderate degree of heat must be applied, as too great a temperature will cause the body to be too dense, and prevent absorption; it will therefore be necessary to fire such articles in the easy parts of an earthenware biscuit oven.

Ironstone.—(*a*) 300 parts Cornish stone, 250 Cornish clay, 200 blue or brown clay, 100 flint, 1 blue calx.

(*b*) 175 pts. Cornish stone, 150 Cornish clay, 90 blue or brown clay, 35 flint, 5 body frit, ½ blue calx. These bodies are very ductile, and fire at the temperature of the common biscuit oven; each piece of ware should be perfectly dry when placed in the seggars, because they are made a great deal thicker than any other kind. Setters also should be used at the bottom of each piece, and ground flint applied, but not sand, for the placing or seating; the body, when burned, is quite vitrified, and the pieces of ware are strong and heavy, ringing remarkably shrill.

Jasper.—10 parts chalk, 10 blue clay, 5 bones, 2 flint, 1¼ blue calx. All the materials should be ground together, as much depends on the different articles being well united, which adds greatly to the fineness in colour and lustre. It fires at the temperature of earthenware ovens.

Lilac Porcelain.—200 parts bones, 115 Cornish clay, 25 blue clay, 20 flint, 15 chalk, 10 Cornish stone, 1¼ blue calx.

Porcelain.—(*a*) 360 parts bones, 230 Cornish clay, 50 Cornish stone, 20 flint, 20 blue or brown clay, 10 body frit, ½ blue calx.

(*b*) 400 parts bones, 360 Cornish clay, 250 Cornish stone, 20 flint, ⅔ blue calx.

Printed Earthenware.—(*a*) Superior.—3 parts blue clay, 1 black or brown clay, 2 Cornish clay, 1¼ flint, ¼ Cornish stone.

(*b*) Common.—2 parts blue clay, 2 brown or black clay, 1 Cornish clay, 1¼ flint.

Ring.—150 parts blue clay, 100 Cornish stone, 100 bones, 52 plaster.

Used for making rings and setters, for placing porcelain and ironstone; the porcelain clay which gets dirty or injured by working may be used for the same purpose, in the proportion of two of the former to one of the latter.

Saucer Mould.—10 parts flint, 4 blue clay, 2 Cornish clay, 1 black clay. Prepared for the sole purpose of making moulds, principally those of saucers; moulds made in this way are preferable, and considerably more durable than those which are made of plaster; the contraction of this clay in burning is inconsiderable.

Stone.—480 parts Cornish stone, 250 blue and brown clay, 240 Cornish clay, 10 glass, 1 blue calx. This body will be sufficiently vitrified at the temperature of the earthenware biscuit oven, and is adapted for the purpose of manufacturing jugs, mugs, and so on; it is requisite to place rings on each piece of ware, in order to keep them from being crooked when burnt in the oven; in all other respects to be treated as earthenware bodies.

Stone Mortar.—480 parts Cornish stone, 250 blue and brown clay, 240 Cornish clay, 10 glass, principally used for making stone mortars, and when burnt is of a yellowish white, absolutely vitrified, exceedingly strong, very durable, and produces a clear bell sound.

White.—50 parts chalk, 50 blue clay, 25 bones, 10 flint. This body is of the same consistency, and requires the same temperature as the jasper body. It is perfectly adapted also for the purpose of figures in bas-relief, and other ornamental work.

Coloured Clays.—These clays are for the purpose of painting porous coolers and bottles in the Mosaic style, and are equally applicable to the ornamenting of china and earthenware; the mixtures must be well ground, for their fineness has a great tendency to equalise the contraction and expansion of bodies in firing.

Black.—4 parts black Egyptian clay, 1 white clay, 1 blue clay.

Blue.—30 parts white clay, 1 blue calx.

Green.—12 parts white clay, 1 nickel, $\frac{1}{4}$ blue clay.

Orange.—4 parts yellow clay, 2 Cornish clay, 1 flint, $\frac{1}{4}$ Cornish stone.

White.—4 parts blue clay, 2 Cornish clay, 2 flint, 1 Cornish stone.

Colours under Glaze, with the exception of the green, should be mixed together and calcined in a reverberatory furnace or glazing oven, in seggar hillers, or dishes lined with flint; then spread on the mixture about an inch in thickness, observing that the hiller or dish have a sufficient access of air allowed, to prevent the metals from reviving again in their metallic state; the green ingredients only require grinding.

Naples Yellow.—12 parts white-lead, 2 diaphoretic antimony, 1 crude sal ammoniac, $\frac{1}{2}$ alum. Mix intimately, calcine in a crucible, over a slow fire, for the space of three hours, stirring it nearly the whole of the time, when the mass will be found of a beautiful yellow or gold colour.

Lining Brown.—7 parts glass of antimony, 3 raw litharge, $2\frac{1}{2}$ manganese, 1 nitre, 1 blue calx.

Painting Brown.—5 parts glass of antimony, 5 raw litharge, 2 manganese, $\frac{1}{2}$ blue calx.

Orange.—6 parts raw litharge, 4 crude antimony, 2 crocus-martis, 1 tin oxide.

Yellow.—4 parts raw litharge, 3 crude antimony, $1\frac{1}{2}$ tin oxide.

Printed Brown.—5 parts raw litharge, 5 crude antimony, $2\frac{1}{2}$ manganese, 1 blue calx.

Printed Black.—3 parts red-lead, $1\frac{1}{4}$ antimony, $\frac{3}{4}$ manganese. After these ingredients have been calcined, add the following, and calcine again: 2 parts blue calx, $\frac{1}{4}$ tin oxide. This black under glaze, in the last stage of preparation, must be calcined in the highest heat of a biscuit oven, and crystal glaze is the most suitable to it. The ware must be fired in an easy part of the glazing oven; the brown calcined in the usual way, and dipped in the common printed glaze.

Printed Mulberry.—4 parts manganese, 2 blue calx, 1 nitre, ½ borax. Calcine this colour in the usual way, either in a dish or seggar hiller, and after the mixture is spread on the dish or hiller, a small quantity of pounded nitre should be scattered thinly over, and when calcined, add 2 parts flint glass, 1 flint; then grind all the ingredients up together for use.

Green for Edging.—3 parts copper oxide, 3 flint glass, 2 flint, 2 tin oxide, 1 enamel blue. Grind these ingredients together, after which add 8 qt. earthenware printed glaze, and 4 qt. cream-colour glaze, mix well together, and sift them through a fine lawn. Lay this green on the ware after it is dipped, and fire it in the coolest part of the glazing oven.

Blue Printed Flux.—(*a*) 2 parts flint, 1 frit for glazes, ½ flint glass. (*b*) 5 parts flint, 1½ borax, ½ nitre. (*c*) 3 parts flint glass, 2½ flint, 1 nitre, 1 borax.

Painting and Edging Blue.—2 parts blue calx, 3 frit for glazes, 1½ flint glass, 1 flint, ½ white-lead. The frit should be prepared without the tin oxide, when mixed with the blue calx, for that metal and arsenic are both prejudicial to its colour.

Strong Printing Blue.—2 parts blue calx, 3 blue printed flux.

Weak Printing Blue.—1 part blue calx, 4 blue printed flux (*b*).

Enamels and Fluxes. — The enamels, after being finely ground, should be thoroughly dried; then mixed up with turpentine, and used like other colours with a pencil; after which fused again, and vitrified by fire. Spirits of tar may be substituted instead of turpentine in all enamels, with the exception of blue and colours prepared from chrome. With regard to the burning, the lustres will bear the highest temperature of an enamelling heat; the rose colour, cornelian red, and pomona green require a less degree of heat, and are generally placed in the middle of the kiln or muffle, as well as burnish gold; other colours are not so susceptible of being destroyed by heat, and will fire in any part of the kiln or muffle. The even surface of the various coloured grounds on china is produced by first laying the space wanted with linseed oil, previously boiled with a little red-lead and a small portion of turpentine; the enamel colour is then ground fine, and dusted on the oiled part with cotton wool, or laid on with a large camel-hair pencil. The component parts of the different colours are as accurately stated as possible, but the preparation principally depends on observation, therefore experiments will be necessary that a proper judgment may be formed.

Balsam of Sulphur.—Take 2 parts flowers of sulphur, and 4 of turpentine; put them in a vessel over a slow fire until the sulphur is completely dissolved; after which add 8 parts linseed oil, and continue the same degree of heat for about one hour; previous to becoming cold, strain it through a piece of cloth.

Black Enamels.—Copper black is a very fine colour, the obtaining of which altogether depends upon a proper temperature of heat being applied, for nothing is more fickle and uncertain; if in the least degree overfired, the colour is destroyed, and becomes of a dirty green. The other blacks are called umber blacks, and will stand any degree of heat which is required in an enamelling kiln or muffle. The umber to be highly calcined in a biscuit oven, but particular caution should be observed that it is the real Turkey umber, and not the English, which is of an inferior quality. The two first enamel blacks to be calcined in the usual way; the materials of the two latter only want grinding.

Enamel Painting Black. — 4 parts borax, 2 calcined umber, 2½ red-lead, 2 enamel blue, 1 flint, 1 blue calx. A superior black enamel is composed by uniting with 8 parts of this composition, 1 enamel, 1 enamel purple.

Enamel Printing Black.—1 part calcined umber, 1¼ calcined borax, ½ blue calx.

Copper Black Enamel.—1 part copper calcined, 3 enamel flux (*a*).

BLUE ENAMELS.—For these the materials must be calcined in an air furnace or glazing oven, and caution should be observed that they are not too finely ground at the mill, in order to prevent them from crazing or chipping after being burnt on the pieces of ware. (*a*) 16 parts flint glass, 5 red-lead, 2 white enamel, 2 blue calx, 1 common salt, 1 potash. (*b*) 16 parts flint glass, 5 red-lead, 2 nitre, 2 potash, 2½ blue calx.

Blue Calx.—(*a*) 30 parts refined regulus of zaffre, 1 plaster, ½ borax. (*b*) 30 parts refined regulus of cobalt, 1 plaster, ½ borax. These materials to be made very fine, and well mixed; put the mixture in earthenware biscuit cups 1½ in. high, 3 in. diameter, and 1½ in. thick, filled nearly to the top; set them in a furnace, the fire to be increased until the mixture is in a state of fusion; the same degree of heat must be continued for about six hours afterwards, and then the fire hastily slackened; this operation will occupy 12–13 hours; at the top of the cups will be found a blue calx separated from the nickel; but as a large proportion of blue will still remain in the nickel when sunk to the bottom of the cups, it will be necessary, in order to procure the whole of the blue contained, to pursue precisely the same method over again.

Cobalt Blue or Regulus of Cobalt.—60 parts cobalt ore, 50 potash, 25 sand, 10 charcoal. Work the same way as for regulus of zaffre.

To Refine Regulus of Cobalt.—50 parts regulus of cobalt, 6 potash. Refine as for regulus of zaffre; the operation of refining must be repeated until the scoria is of a bright colour and of a slight bluish hue; then spread the purified metal, finely pulverised, ½ in. thick, on flat pieces of earthenware covered with flint; place in a reverberatory furnace, and apply a moderate degree of heat for a few hours.

Smalts.—32 parts sand, 32 potash, 10 borax, 1 blue calx. These smalts, the materials of which are calcined in the usual manner when finely pulverised will produce a fine rich-looking blue powder.

Regulus of Zaffre.—112 parts zaffre, 57 potash, 18½ charcoal. The charcoal being pulverised, and all the materials mixed up together, they are put into large-sized crucibles capable of holding 3–4 qt., and filled quite full, then placed in a strong brick-built reverberatory furnace, commencing with a slow fire, and continued for some time, but as soon as it is heated to a red-heat, it will require a considerably stronger fire before the cohesion between the different particles is sufficiently destroyed. This operation will be complete in about ten hours, the weight of the regulus being 31–33 lb.; on examining the scoria, if there remains mixed with it small pieces of metal like small shot, or when pounded, if the scoria has a bluish cast, the fire has not been strong enough; there is but little danger to be apprehended from the most intense heat, provided the particles in fusion do not perforate the crucibles. At the bottom of each cake of regulus there will be bismuth slightly adhering, which is easily separated without the application of any great degree of heat, by placing the cakes upon an iron plate or pan, which will soon bring the bismuth into a state of liquefaction, and it can then be separated from the regulus.

To Refine Regulus of Zaffre.—50 parts regulus of zaffre, 6 potash, 3 sand, pulverise and well mix, then put in crucibles holding about 1½ lb. each, and fire in a reverberatory furnace, commencing with a slow fire and gradually increase the heat for about eight hours; by that time the regulus will have fallen to the bottom of the crucible, and the scoria found at the top will be of a blackish green, it will then be necessary that another course of refining should take place, in order that the regulus may be obtained in a more perfect state of purity.

Brown Enamels, *Dark.*—1 part copperas calcined brown, 2 enamel flux (*d*), ¾ enamel flux (*a*). Brown enamel only requires grinding before it is fit for use; the copperas for the purpose of making dark brown will require calcining in the most intense heat of a biscuit oven; the colour of it varies according to the temperature it undergoes, first white, then orange, red, and lastly brown.

Light.—1 part calcined umber, 1 yellow under glaze, ½ copperas calcined red, ¼ white enamel, 4½ enamel flux (*b*), 3 enamel flux (*c*).

ENAMEL FLUX.—(*a*) 8 parts red-lead, 6 flint glass, 3 borax, 3 flint. (*b*) 7 parts red-lead, 4 borax, 2¼ flint. (*c*) 4 parts borax, 3 red-lead, 3 flint glass, 2 flint. (*d*) 3 parts red-lead, 1 flint glass, 1 flint.

GOLD FLUX.—11 parts borax, 5½ litharge, 1 silver oxide. In these enamel fluxes the materials are to be made very fine, particularly the flint, and mixed well together, so that the particles may more easily concrete when in a state of fusion; then calcined in an air furnace or an earthenware glazing oven, when the whole mass, by means of the proper temperature of fire, will be changed into a brittle resplendent and transparent glass.

Gold Bronze.—2½ parts burnish gold, 2 copper oxide, 1 quicksilver, ¼ gold flux. Having dissolved the copper in aqua fortis, it is again separated from its solvent, and falls to the bottom of the vessel by the addition of iron; the precipitate of copper may be increased or diminished at discretion, which makes the bronze richer or poorer in colour according to the proportion of burnish gold contained in the mixture. It is chiefly used for ornamenting the handles and heads of jars, vases, and so on, and occasionally intermixed with burnish gold.

Gold Solution. - Put 40 dwt. aqua regia in a small bottle, to which add 5 dwt. grain gold; the solution will immediately commence, and may be observed by the effervescence which arises at the time; when the solution is complete, the whole of the gold will be dissolved, which will be accomplished in about two hours if the acids be genuine, but when they are not, it will be requisite to apply heat to facilitate the solution.

Burnish Gold from Brown Gold.—12 parts brown oxide of gold, 8 quicksilver, 2 silver oxide, 1 white-lead. Put the whole of these ingredients into an earthenware mortar, and triturate them until the whole is amalgamated; the mercury being the solvent fluid, very readily combines with the rest, to which it communicates more or less of its fusibility, after which grind them very fine with spirits of turpentine.

Burnish Gold from Green Gold.—12 parts green gold, 7½ quicksilver, 1½ silver oxide, 1½ gold flux. Place the gold in an earthenware vessel on an open fire, and when heated red hot, take four times its weight of mercury, and pour it in; the mixture to be stirred with a little iron rod; the gold will be dissolved; it is then thrown into a vessel full of water until it coagulates and becomes manageable; much of the mercury is then pressed through a piece of leather, and the rest is dissolved by a quantity of nitrous acid; the acid is afterwards poured off, the gold remaining is repeatedly washed with boiling water as often as needful; it is then dried and mixed up with the other ingredients, and ground with spirits of turpentine for use.

Gold Lustre.—Take grain gold and dissolve it in aqua regia, as for solution of gold; add 5 gr. tin; an effervescence takes place when the solution is completed and in a proper condition to be mixed; take balsam of sulphur 3 parts, spirits of turpentine 2 parts, mix them well together over a slow fire, then gradually drop the solution of gold into the menstruum, and keep stirring until the whole solution be added; provided the mixture should appear too thick, add more turpentine till of a proper consistency. 1 oz. gold dissolved in the manner described will make upwards of 2 lb. prepared lustre, and must be used with turpentine, for all other spirits are injurious.

Persian Gold Lustre. — Take any quantity of the precipitate of gold, first mixed with a small portion of fat oil on a flat piece of earthenware, then place it on a stone previously heated, and when the mixture begins to be in an eliquated state, stir it well with a palette knife, and keep adding more oil by a little at a time, until with the continuance of a gentle heat it assumes the colour of balsam of sulphur, then add, with a less degree of heat, turpentine in small quantities. 1 oz. of the precipitate of gold will make about 1 lb., more or less, of lustre, having more solidity and opacity than gold lustre. The proportions of the fat oil of turpentine to the spirits of turpentine, are 1 part of the former to 3 of the latter.

Green Enamels. — *Blue Green.*—42 parts red-lead, 15 flint, 12 borax, 2¾ blue vitriol calcined. To these materials, after being calcined in an air furnace or glazing oven, must be added 12 parts white enamel, then grind them all together.

Grass Green.—3⅔ parts blue green frit, 1 enamel yellow.

Yellow Green.—2½ parts blue green, 1 enamel yellow.

Pomona Green.—1 part oxide of green chrome, 2½ enamel flux (*a*), 1½ enamel flux (*d*). This green is prepared by simply grinding the ingredients, and produces that dark colour equal to the French green, provided the oxide is genuine; and by adding a proportion more of flux and white enamel, there still will be a rich tint, though weaker and lighter in colour.

Orange Enamel. — 1 part orange under glaze, 2 enamel flux (*a*), 1 enamel flux (*d*).

Platinum Lustre.—Dissolve platina as for silver lustre. Let the solution fall into a large vessel of water at the temperature of blood-heat; the sal ammoniac must then be added, and the precipitate will immediately descend to the bottom of the vessel in an orange-colour powder; decant off the water, and repeatedly apply to the precipitate boiling water until the water becomes quite insipid; after being gradually dried it is then used for the purpose of producing a silver lustre in the following manner:—First, procure brown earthenware of a full soft glaze, and with a broad camel-hair pencil lay on all over the piece of ware the platina in solution, and fire it at a strong enamelling heat, by which it will acquire a shining steel-colour lustre; then take the platina oxide mixed up with water to a thickish consistence, and lay it on the steel lustre, and fire it again in a kiln or muffle, but not to exceed a blood-red heat; it is then called silver lustre, being less resplendent, having more solidity and whiteness, and a very similar appearance to silver. On all white earthenware the platina in solution is perfectly sufficient to produce a silver lustre.

Purple Enamel.—4 parts gold in solution, 1 tin in solution. Procure a vessel to contain 50 parts of water about the temperature of blood-heat, to be well mixed with the solution of gold, and then add the solution of tin by dropping it into the menstruum, at the same time constantly stirring it with a strong feather, which will produce a fine purple-colour liquor; but it will be necessary to add a few drops of the solution of silver, which will much assist to raise the colour and beauty of the purple; to help the precipitation of the gold from its solvent (provided the precipitation does not immediately take place) add a large proportion of boiling water or a small quantity of sal ammoniac, and a precipitate will instantly be procured; the clear liquor must then be decanted off, and the boiling water repeated until it is completely insipid. The residue consists of the oxides of gold, tin, and silver in combination, and is the only substance which has the property of communicating the purple colour to enamel glass; after the precipitate is prepared, the flux must be added; the proper quantity will solely depend on the fusibility or softness of the flux, and as the operation in a great measure depends on observation, a few experiments by the operator will be found useful. To the purple precipitate may be added 30–45 enamel flux (*c*), according to the strength of colour intended to be made.

Purple Distance.—2 parts enamel purple, 3 manganese oxide, 12 enamel flux (*c*).

Red Enamels.—1 part green copperas calcined, 3 enamel flux (*c*). The greatest difficulty in preparing red is the calcination of the copperas; calcine the copperas in a vessel exposed to the heat of an open fire, by which means it will dissipate all its volatile contents, and leave a residue of iron oxide in powder; when it attains an orange or light red, the calcination is sufficiently accomplished; the residue is then washed repeatedly with boiling water, until the water becomes insipid and free from sulphuric acid.

Cornelian Red.—1 part iron chromate, $3\frac{1}{2}$ enamel flux (*d*). This fine colour is produced from iron chromate, which has a greater affinity for lead than an alkali, consequently the flux prescribed is the only one which is susceptible of yielding its proper colour, as those fluxes which contain a large proportion of borax are very prejudicial, destroying the colour, and with the greatest difficulty forming any affinity at all, therefore should be avoided. The flux used should be highly calcined until it assumes a dark orange-coloured glass. Mix up with spirits of turpentine when dry.

Rose Colour.—3 dwt. gold in solution, 60 leaves book silver, $2\frac{1}{2}$ lb. enamel flux (*a*). Procure a vessel to contain 10 parts the quantity of hot water, then mix the water and gold together while the water is at the temperature of 190° F.; add pulverised sal ammoniac rather copiously, at the same time briskly stirring the mixture with a strong feather, until the appearance of a decomposition takes place, which will soon be observable by the gold being precipitated from the menstruum in the form of a fine yellow powder; when that is accomplished, let the vessel stand undisturbed a short time to allow the precipitate to subside, then decant the liquor off, and still add boiling water repeatedly to the precipitate until the water is perfectly insipid; in the next place put it on a plaster bat to dry, after which it must be mixed up with book silver and flux, according to the proportions given above, and well triturated in a mortar; then send it to the mill to be ground, when it will be in a proper state for use. This colour is supposed to be best when of a purple tinge, which may be produced by merely calcining the preparation to the heat of ignition previous to being ground; if the colour be too dark, the mixture does not possess a sufficient quantity of silver; if it is too light, the silver must have been very plentifully added, therefore the operator must add or diminish accordingly. Great caution must be observed with this receipt, as the gold precipitated by the sal ammoniac will unite with it, and then has the property of fulminating; and when gently heated or smartly struck with any hard instrument will immediately detonate; this can only be obviated by a plentiful use of boiling water; a caution which ought to be strictly attended to, as it removes the dangerous quality by depriving the gold of its salt.

SILVER or STEEL LUSTRE.—This is prepared by taking platina and dissolving it in aqua regia composed of equal parts of spirits of nitre and muriatic acid. The solution must be placed in a sand bath at a moderate temperature; then take 3 parts of the spirits of tar, and 1 part of the solution of platina, mixing the solution with the tar very gradually, for as soon as the combination takes place, an effervescence will arise, the nitrous acid will evaporate and leave the platina in combination with the tar. After the above process has been performed, should the menstruum be found too thin and incapable of using, set it on a sand bath as before for a few hours; the spirit of the tar will evaporate, and by that means a proper consistence will be obtained. It must be used with spirits of tar.

Silver Solution.—1 part nitric acid, and 3 of boiling water; add one-third of its weight of silver, dilute with five times its quantity of water, then add a portion of common salt, stirring it all the time; immediately a white precipitate will fall to the bottom of the vessel; the liquor must then be decanted off and boiling water repeatedly added, until the water is quite insipid. This precipitate is the pure oxide of silver, and is the same as that used in the preparation of burnished gold.

TIN SOLUTION.—2 parts nitrous acid, and 1 part muriatic acid, with an equal part of water; add granulated tin by small pieces at a time, so that one piece be dissolved before the next is added. This aqua regia will dissolve half its weight of tin; the solution when properly obtained is of a reddish brown or amber colour, but when gelatinous the solution is defective.

Tin Oxide.—Take any given quantity of grain tin, and melt in an iron ladle; when in fusion, pour it into a vessel full of cold water, by which means the tin will be reduced into small grains or particles adhering to each other; then take a biscuit dish previously lined with flint, spread it slightly over with pounded nitre, take the granulated tin, and lay it on the dish 2 in. thick, adding a little more nitre on the top; 1 lb. nitre will be sufficient to oxidise 5 lb. granulated tin; the dish containing the tin and nitre is to be calcined in a reverberatory furnace or glazing oven; particular attention is required in seating it, so that plenty of room remains to admit a free access of air to pass over the metal, otherwise it is impossible to obtain the whole of it in an oxidised state.

WHITE ENAMELS.—These require the materials to be made very fine and calcined in air furnace, the heat at first to be generated very gradually; and when the whole mass is in a state of fusion increase the fire quickly, and there will soon be produced a fine white enamel; in the time of fusion it will be requisite to keep stirring the whole together with an iron spatula or rod.

Venetian White.—3½ parts flint, 3 calcined borax, 1 Cornish stone, ½ tin oxide.

Common White.—8 parts flint glass, 2 red-lead, ½ nitre, ½ arsenic.

YELLOW ENAMEL.—1 part Naples yellow, 2 enamel flux (*a*), 1 enamel flux (*c*).

Glazes.—ALKALINE.—30 parts borax, 30 flint, 18 Cornish stone, 2 tin oxide. The materials must be calcined, and particular caution observed in the course of chipping from the seggars, that not the least particle of any colouring matter be mixed with it, for it is very susceptible of being materially injured in its colour; when ground, a small quantity of muriatic or nitrous acid should be added, and at the same time quickly stirred about, and the motion continued for some time, in order to prevent it setting at the bottom of the vessel; in all other respects treated the same as common glazes, except with regard to dipping, in which case it must be used very thin.

BLUE.—50 parts flint, 30 borax, 22 red-lead, 10 Cornish stone, 6 crystallised soda, 6 tin oxide, 3 blue calx. In preparing this glaze follow the same directions as for porcelain glaze.

Blue and Green Edge.—72 parts litharge, 36 Cornish stone, 20 flint glass, 17 flint, 12 frit for glazes (*b*), ⅕ blue calx. The blue and green edged ware when dipped in this glaze should be perfectly dry previous to being placed in the seggars, and the green edge should be seated in the coolest part of the glazing oven.

BROWN COTTAGE.—60 parts litharge, 32 flint, 8 brown slip. This glaze requires using about the same consistency as the cream-colour glaze, and will stand the highest temperature of heat in a common glazing oven.

CALCEDONY.—65 parts litharge, 40 Cornish stone, 20 flint, 6 frit for glazes (*b*).

COMMON PRINTED.—90 parts white-lead, 45 Cornish stone, 22 flint, 20 flint glass, ¼ blue calx. To this, after being properly ground and sifted, add 1 lb. common salt and ½ lb. borax, which forms a smear or flow, as it is generally termed, but must not be put into the glaze until the blue stain is perfectly incorporated with it; the ware dipped therein must be placed in seggars washed with glaze.

CREAM-COLOUR.—(*a*) *Superior.*—85 parts white-lead, 40 Cornish stone, 22 flint, 16 flint glass, 8 frit for glazes (*b*).

(*b*) *Common.*—75 parts litharge, 40 Cornish stone, 23 flint, 10 flint glass.

CRYSTAL.—105 parts Cornish stone, 90 borax, 60 flint, 50 red-lead, 12 crystal soda, 10 tin oxide, $\frac{1}{4}$ blue calx. This glaze produces very superior white earthenware, and, for the purpose of enamelling, the colours, lustres, and burnished gold appear to considerable advantage; it is also adapted for ironstone, and makes superior blue printed earthenware; it has a singularly striking effect on printed brown and mulberry. When used for dipping it must be considerably diluted, and requires but little shaking from the hand of the operator. It requires the heat of a china glazing oven, but to answer the earthenware oven a small addition of white-lead must be made, according to the temperature of firing. The materials must be mixed and calcined, and the ware fired in lime aud slip seggars, well washed.

DRAB.—70 parts litharge, 30 flint, 25 Cornish stone, 10 drab slip.

EARTHENWARE PRINTED.—(*a*) *Superior.*—90 parts white-lead, 35 Cornish stone, 20 flint glass, 20 flint, 60 frit for glazes (*b*), $\frac{1}{4}$ blue calx.

(*b*) *Common.*—85 parts white-lead, 35 Cornish stone, 22 flint, 15 flint glass, 24 frit for glazes (*b*), $\frac{1}{5}$ blue calx. These glazes, when ground, to be sifted through a fine lawn; the former glaze is of the finest texture, and will require rather a thinner coatiug when dipped than those of common glazes. Fire in seggars, either washed with common glaze, or a mixture of lime and slip without flint.

FRIT BODY.—60 parts Cornish stone, 40 flint, 30 crystal soda, 8 tin oxide, 10 borax. This frit is used in small quantities, in china and ironstone bodies.

FRIT FOR GLAZES.—(*a*) 40 parts Cornish stone, 36 flint glass, 20 red-lead, 20 flint, 15 potash, 10 white-lead, 3 tin oxide. This frit is intended to be used in glazes, in lieu of those which contain a large proportiou of borax; therefore substituting it when the price of that article is high, will, of course, be advantageous, and the texture of the glaze will still be good and admissible.

(*b*) 36 parts Cornish stone, 30 red-lead, 20 flint, 20 borax, 15 crystal soda, 5 tin oxide. These two frits may be calcined in the easy part of the glazing oven, in seggars lined with flint; particular care should be observed that they are clean chipped, and free from pieces of seggars, or any dirty substance.

GREEN.—3 parts blue vitriol, calcined, 1 flint glass, 1 flint. When ground, take 4 qt. of this mixture to 30 of the following mixture, ground:—35 parts litharge, 20 flint, 10 Cornish stone, 10 frit for glazes. This glaze is sufficiently fired in the coolest part of the glazing oven. Particular attention should be observed as to the proper wash used for the seggars, for much depends on that simple process. The brightness and lustre of the glaze will be secured by adopting the following wash:—5 parts solution of quicklime, 1 of clay slip, free from the least particle of flint, and applied about the thickness of common glaze.

IRONSTONE.—36 parts Cornish stone, 30 borax, 20 flint, 15 red-lead, 6 crystal soda, 5 tin oxide, $\frac{1}{8}$ blue calx. With the above frit is to be added 15 parts white-lead, 10 Cornish stone, 10 flint, when ground together, the composition is ready for use; should the glaze prove too thin for dipping, add a small quantity of muriatic acid.

PORCELAIN.—40 parts Cornish stone, 45 red-lead, 38 borax, 32$\frac{1}{2}$ flint, 22$\frac{1}{2}$ flint glass, 13 crystal soda, 5 tin oxide, 1 enamel blue. The particles are made small and well mixed together, then calcined in the coolest part of the glazing oven, in seggars thickly lined with flint; care must be observed that the frit is not too highly calcined, or brought iuto a high state of vitrification; if so, it will render it difficult to grind, and injure its good qualities in dipping. The frit likewise if too finely ground will cause the glaze to be uneven on the surface of the ware; if any inconvenience of this nature arises, by addiug a solution of potash in hot water, that defect will be instantly obviated.

WHITE EARTHENWARE.—35 parts Cornish stone, 20 borax, 10 crystal soda, 20 red-lead, $\frac{1}{5}$ blue calx. Calcine and then pulverise coarsely, and grind with 20 lb. white-lead, 10 lb. Cornish stone, and 5 lb. flint.

Printing Oil for Pottery.—(*a*) 1 qt. linseed oil, 1 pint rape oil, 2 oz. balsam capivi, 1 oz. pitch, ½ oz. amber oil, ½ oz. white-lead.

(*b*) 1 qt. linseed oil, ¼ pint rape oil, ¼ pint common tar, 1 oz. balsam sulphur, 1 oz. balsam capivi. The linseed oil should be boiled for some time alone, then add the rape oil and the balsam capivi, allow the boiling to be continued until it begins to approach the proper consistency, and add the remaining ingredients. The mixture should be allowed to cool a short time, after which the whole mass may be boiled slowly until it has assumed the proper thickness; the vessel must be generally covered during the process, and the sulphur previously to being mixed with the oil should be perfectly pulverised, as by that means it is less liable to curdle the oil.

Stains for Pottery.—In preparing these stains the ingredients must be ground remarkably fine, and then so perfectly dried as not to leave the least humidity, after which they must be ground again with oil prepared for the purpose, composed of 2 parts balsam of sulphur, 1 part amber oil, and as much turpentine as will render them of a proper consistency; they may then be used with ease for painting various devices on biscuit ware.

BLUE.—5 parts blue calx, 2 frit for glazes, without tin oxide, 1 flint glass, 1 enamel blue.

GREEN.—3 parts blue stain, 1 yellow stain, ½ enamel blue green.

YELLOW.—3 parts yellow under glaze, 1 frit for glazes, ¼ chromate of iron.

PRINTERS' ROLLERS.

(*a*) To 8 lb. transparent glue add as much rain or river water as will just cover it, and occasionally stir it during 7 or 8 hours. After standing for 24 hours, and all the water is absorbed, submit it to the action of heat in a water bath, that is, surrounded by water, as glue is generally heated, and the glue will soon be dissolved. Remove it from the fire as soon as froth is seen to rise, and mix with it 7 lb. molasses, which has been previously made tolerably hot; stir the composition well together in the water bath over the fire, but without suffering it to boil. After being thus exposed to the heat for half an hour, and frequently well stirred, it should be withdrawn from over the fire and allowed to cool for a short time, previous to pouring it into a cylindrical mould made of tin, tinned sheet iron, or copper, having a wooden cylinder previously supported in its centre by means of its end-pivots or gudgeons. After remaining in the mould at least 8–10 hours in winter, and a longer time in summer, the roller is to be taken out of the mould by means of a cord fastened to one of the gudgeons, and passed over a strong pulley fixed to the ceiling; but care must always be taken that the cylinder is drawn out slowly from the mould. Old rollers are recast in the same manner, first taking care to wash them with a strong alkaline lye, and adding a small quantity of water and molasses. The best mode, however, of making use of the old composition, is by mixing it with some new, made of 2 lb. glue and 4 lb. molasses.

(*b*) Composition for rollers:—Summer use, 1½ lb. best glue and 4 lb. treacle; winter use, 1 lb. best glue and 4 lb. treacle. Soak the glue about 1½ hour if thick, if thin 1 hour. Take it out of the water, lay it on a board until next day, then melt down in proper melting pot, or put it in a saucepan and place it in another containing water. Do not let the water run over into the glue; one great secret in roller casting is to have as little water in the glue as possible. Add treacle as above, let boil once, then keep it just under boiling-point until cooked, which takes about 2 hours, more or less; pour out into moulds, well cleaned and greased; if the composition is left too long on the fire it will get thick and spoil. The above is sufficient for an 18-in. roller; other sizes in proportion.

Recovering Waste Metal.

The recovery of metal from waste solutions and scraps is usually a very simple matter and generally affords more than sufficient profit to pay for the trouble and expense incurred.

Copper Salts.—Collect all the liquids holding copper in a large cask filled with wrought or cast iron scraps; a chemical reaction immediately takes place, the iron is substituted for the copper to make a soluble salt, and copper falls to the bottom of the cask in the shape of a brown powder. The cask should be large enough to hold all the liquids employed in a day's work. The iron scrap should be suspended in willow baskets on the top of the liquor, and, by stirring now and then the liquid with them, the metallic powder of copper will alone fall to the bottom of the cask. The same method may be employed for recovering the copper from old cleansing acids, or from worn out galvanoplastic baths. The copper thus obtained is quite pure; calcining it in contact with the air, gives a black binoxide of copper for neutralising too acid galvanoplastic baths.

Gold.—(*a*) All the liquids which contain gold, except those in which there is a cyanide, are strongly acidulated by sulphuric or hydrochloric acid, unless they are already acid, and then largely diluted with water. Precipitate the precious metal by a solution of sulphate of protoxide of iron (copperas), and, after a few hours standing, it is ascertained that the liquor does not contain any more gold when a new addition of iron sulphate does not produce any turbidity. The precipitated gold is in the form of a red or black powder; collect upon a filter, wash, and dry in an iron pan, with weights equal to its own, of borax, saltpetre, and potash carbonate. Gradually introduce the powder into a refractory crucible heated to a white heat in a good air-furnace. When all is introduced, increase the heat and close the furnace, so that all the metal may fall to the bottom of the crucible. After cooling, extract the button of pure gold which remains. If it is desired to dissolve the powdered gold left on the filter in aqua regia, it will be necessary to wash it several times with dilute sulphuric acid, to remove the iron sulphate with which it is impregnated. This mode of reduction is adapted to an impure gold chloride, to the baths by dipping with soda bicarbonate or pyrophosphate, and also to the ungilding acids; but it is imperfect with baths holding a cyanide, which never completely part with all the gold they contain by this process. The best manner of treating the latter liquors is to evaporate them to dryness in a cast-iron kettle, and calcine the residue to a white heat in a good crucible. A small proportion of borax or saltpetre may be added to aid the fusion, but generally it is unnecessary. The resulting button of gold at the bottom of the crucible is red when saltpetre has been employed, and green with borax; but these differences of colour have nothing to do with the purity of the metal.

(*b*) Gold may be separated from liquors which contain no cyanide, by an excess of tin protochloride, which produces a precipitate easily reduced by heat. Sulphurous acid will also reduce the gold; but in this case, the liquor should be heated. Granulated gold is obtained by running the molten metal, in a small stream, and from a certain height, into a large quantity of cold water.

(*c*) Sweepings, saw-dust, residues from the bottoms of scratch-brushing tubs, filters, papers, and rags, must be collected, mixed, and burned in a furnace constructed for the purpose. The ashes are finely pulverised, sifted, and thoroughly mixed with a quantity of mercury, which combines with the gold and silver. The amalgams, separated by washing, are then distilled in cast-iron retorts of a peculiar shape. The mercury volatilises, and the gold and silver remain in the retort. For separating these metals, granulate the solid mass and treat with pure nitric acid, which dissolves the silver, and is without action upon the gold. The latter metal collects at the bottom of the vessel in a black or violet powder, and is pure, after having been washed in distilled water. If an ingot contains only a little silver and much gold, melt previously with a certain proportion of the former metal, in order to more easily dissolve in nitric acid. The ingots of silver and copper should be boiled in cast-iron kettles with concentrated sulphuric acid, which transforms the copper into soluble sulphate, and silver into sulphate, only slightly soluble. The separation of the two may be partly effected by washing, but, generally, the silver is precipitated by plates of copper. The alloy, previous to its solution, should be granulated.

(*d*) An easy method to recover gold from solutions, particularly from old toning-baths of photographers, has been made known by Haugk. It consists in filtering the solution into a white glass flask or bottle, making it alkaline with sodium bicarbonate, and then adding, drop by drop, a concentrated alcoholic solution of aniline red (fuchsine), until the liquid retains a deep strawberry colour. The flask is then exposed to the sunlight for 6–8 hours, at the end of which all the gold still present will have been precipitated as a dark violet powder, and the liquid will have become colourless. After pouring off the liquid, the flask, with its precipitate, is kept until a fresh quantity of solution has to be precipitated, and this is continued until the deposit in the flask is sufficiently large to make it worth while to remove it. It is then transferred to a filter, washed, dried, and burned with the filter. The residue containing the filter-ash is dissolved at a gentle heat in aqua regia, filtered, and the solution is evaporated to dryness. The quantity of impurity caused by the simultaneous solution of the filter-ash is too insignificant to be objected to.

(*e*) Although sheet zinc, or zinc and iron sheets, serve well for the precipitation of silver, they cannot be employed for the recovery of gold. The latter separates out in such a case very incompletely and as a firmly adhering lustrous film in the zinc. On the other hand, finely divided zinc, the so-called zinc dust, is an excellent substance to employ for precipitating gold quantitatively and in the form of powder from spent cyanide liquors. When zinc dust is added to a spent gold bath and the liquid is periodically stirred or shaken, all the gold is precipitated in 2–3 days. The amount of zinc to be added naturally depends on the quantity of gold present. Freshly prepared gold baths for gilding in the cold contain on the average 3·5 grm. gold per litre; whilst those used for the hot process contain 0·75 grm To precipitate all the gold in the original bath, 1·74 grm. or 0·37—0·5 grm. zinc dust would be necessary, and, of course, a much smaller quantity would be sufficient for the spent liquors. Since the precipitation takes place more rapidly when an excess of zinc dust is present, it is generally advisable to add ¼ or at the most ½ kilo. of zinc dust to every 100 litres of solution.

The precipitated gold, which contains zinc dust and usually silver and copper, is washed, freed from zinc by hydrochloric acid, and then from silver and copper by nitric acid and thus obtained pure.

A spent bath treated in this way gave the following amounts of gold per litre:—

1st experiment ..	0·2626 grm.
2nd „ ..	0·2634 „
Mean	0·2630 „

The presence of gold in the residual cyanide solution could not be qualitatively detected. The potassium cyanide of the solutions obtained by this process should be converted into ferrocyanide by heating with ferrous sulphate and milk of lime, since this substance is not poisonous and can therefore be got rid of without danger. It would, however, be more economical and, considering the large amount of cyanide present, more profitable to work it up into Prussian blue.

Platinum.—(*a*) Render any kind of platinum bath acid by hydrochloric acid, unless it is already so, and then plunge cleansed iron into it. The platinum is reduced to a black powder, wash, and calcine to a white heat. Dissolving it in aqua regia reconstitutes the platinum chloride necessary for the preparation of the baths.

(*b*) Reduce by evaporating the bath to dryness, strongly calcine the residue, then wash upon a filter to remove the soluble salts, and again heat to a white heat. The platinum thus obtained is soluble in aqua regia.

(*c*) In the face of the present high price of platinum, residues and "washes" of this metal are well worth working up. The old developing-baths for platinotype paper, odd bits of the paper itself, spoilt prints, &c., all may be reworked. Old developers may be treated with saturated solution of iron sulphate—1 part of the saturated solution to 4 parts of the developer will be about right; the mixture should be heated to boiling in a porcelain dish, and the precipitated metal collected on a filter. Bad prints, clippings, &c., of the paper, should be placed on a tin or iron plate and burned, the ashes collected and digested for some hours at 122°–158° F. with aqua regia, and then the solution diluted with an equal volume of water, and the platinum precipitated with iron as above, or with ammonium, or soda formate, or any other reducing agent.

Silver.—It is a fact that only about 5 per cent. of the gold and silver used in producing a photograph remains on the finished picture; the balance is lost, and below are given a few short and simple methods of saving and reducing photographic wastes and residues.

(*a*) Old baths and the washings of the prints should be precipitated with ordinary salt, thereby forming silver chloride. Add the salt gradually, stirring up the solution, until it forms no longer a precipitate, which you may easily determiue by taking a sample of it in a tumbler or white bottle, holding it up to the light when adding a little salt. Do not add too much, as an excess will redissolve the chloride. When the silver is all down, pour in a little acid, either nitric, sulphuric, or muriatic, which will clear the solution; allow it to stand for about 24 hours, then draw off your clear water and you have the chloride on the bottom of the vessel.

(*b*) The hypo or fixing solution is very rich. It should be precipitated with potassium sulphide previously dissolved in water, also adding it as long as it will form a precipitate. The latter, when down, may be thrown on a plain muslin filter to allow the water to drain off. Such a filter may be readily constructed by taking a piece of common unbleached muslin, say a yard square, tying loops to the four corners, and hanging it up on sticks.

(*c*) A good many photographers are in the habit of precipitating their washing solutions with metallic zinc expanded in sheets therein. The action of zinc, however, is slow, and must be accelerated by acidifying the solution. Now it frequently happens that the fixing solution is allowed to run into the same vessel, and, the hyposulphite being an alkali, suspends the action of the zinc. In the course of time a deposit out of the water is formed; but the proprietors of the "mud" are sadly disappointed in its value, as it is sometimes even so poor as not to pay for the trouble of refining.

(*d*) All prints should be trimmed before toning, as it saves gold, and, besides, toned paper is of hardly any value. Keep the untoned clippings and filters clean by themselves; do not throw sweepings, pieces of glass, and spoiled ferrotype plates among them, as their bulk only decreases the real value. If you wish to burn the paper, have your stove cleared of cinders and ashes, and proceed slowly, for a good draught will carry many particles of silver through the flue.

(*e*) Your toning solution throw down with iron sulphate, but be sure and have the solution "acid," as otherwise the iron will be precipitated, and your gold goes up the chimney. Save your developer and collodion skins; they will also amount to something in the course of time.

(*f*) Sometimes the wood of barrels which contained waste solutions for a number of years is quite impregnated with silver, some barrels yielding as much as thirty ounces of metal; so, when yours are unfit for further use, you know what to do with them.

(*g*) Last, but not least, do not send small lots of waste to be refined, but wait until you have a reasonable quantity for expenses, and charges are then comparatively less.

(*h*) Common salt is without action upon the liquids which hold silver in the state of a double salt, and will rather aid the solution than the precipitation; such are the double tartrate of silver and potash, whitening bath, the double sulphite of soda and silver, and the bath for dipping. Before employing common salt, add sulphuric acid, which, displacing the other acids, restores the silver to the state of a simple salt. easily precipitated by common salt. Hydrochloric acid alone precipitates silver well from these solutions. Liquors containing silver as cyanide are also exceptions; to extract all the metal, use the process employed for similar combinations of gold, evaporate to dryness, and reduce the mass in a crucible, with an addition of soda carbonate aud powdered charcoal. The metallic silver remains at the bottom of the crucible.

(*i*) Baths of silver cyanide, the residues from galvano-plastic establishments, are precipitated with sulphuric acid. The precipitate contains all the silver, along with copper, zinc, and iron. It is ignited, and the residue is treated with nitric acid, which dissolves out the silver, zinc, and copper. From this solution the silver is thrown down as chloride. The portion insoluble in nitric acid contains carbon, ferric oxide, and traces of silver, which may be extracted with ammonia.

(*k*) Filter the solution of silver proposed to be operated upon until it is clear, and place the filtrate in a clean white bottle of suitable capacity. To each pint of the liquid add 4 oz. or more of mercury, and allow the mixture to remain at perfect rest for a few days. In a very few hours a beautiful sparkling coruscation will be found forming upon the surface of the mercury by what is known as double elective affinity, and for each atom of the silver so deposited, a corresponding amount of mercury is acted upon by the nitric acid of the silver, and passes into solution as mercury nitrate. The deposition continues until all the silver has been thrown down, when we find over it a strong solution of mercury nitrate, which may be obtained in the solid crystalline form by evaporation. In a few days the deposition will be completed, which can be readily seen if the tree ceases to grow. Shake the bottle thoroughly, so that the branches of the tree are detached and broken, and brought in thorough contact with the mercury, where the spangles of silver are quickly dissolved. The watery part of the mixture can now be drawn or decanted off from the mercury, and the latter placed in a bag, or, better, in a large piece of fine tough buckskin, and pressed with force between the hands. When no more mercury can be squeezed through, the bag may be opened and the lump of brittle amalgam removed, and preserved in a well-cleaned and stoppered bottle until more has been accumulated. In case all the mercury should disappear at the end of the process, a little more may be added to the watery solution to ascertain whether it still contains silver.

(*l*) A method of reducing silver chloride to the metallic state, especially adapted to the practice of amateurs, formed the subject of a paper read before the Manchester Photographic Society recently by Mr. J. Leigh.

Many amateurs, said the author, trouble themselves very little about the reduction of photographic silver wastes, simply because they consider their small quantities not worth sending to a professional refiner, or that the process of reduction to the metallic state is troublesome, and not worth the expense. The process about to be described is simple, effectual, and economical, and particularly suited to the amateur who has comparatively small quantities to operate upon. As regards the precipitation of Ag Cl from solutions containing $Ag\ NO_2$ we all make use of common salt. In my dark room is a large inverted bell-glass, into which are poured the washing waters of dry plates and paper prints, the rinsings of glasses, baths, and other vessels which have contained $Ag\ NO_3$ in solution; and, at the end of the season, all the nitrate baths are added to be precipitated as Ag Cl by the process just mentioned. The precipitated chloride should be well washed by decantation, dried, and weighed, or it may be poured into the evaporating basin without washing. Add to the Ag Cl about its own weight of KOH, or NaOH, and half its weight of cane sugar, with sufficient water to well cover the whole, and boil for about 15 minutes over a Bunsen's burner. This solution turns muddy on applying the heat, but in a few minutes gets somewhat clearer, owing to the reduction of the silver, which settles on the bottom of the basin in the form of a grey powder, lacking altogether the metallic lustre of silver cast into ingots or buttons. The finely-divided silver is transferred to a precipitating beaker and well washed by decantation. The clear washing water is now tested with $Ag\ NO_3$ until no precipitate is obtained; the silver is then washed in two changes of distilled water. There is nothing new in the above process; it is based upon the fact that solutions of sucrose or dextrose in the presence of alkalies, reduce the salts of the noble metals to the metallic state; the chlorine, in the case of chlorides, remaining in solution.

At the commencement I stated that this was an effectual method of reducing Ag Cl, which I think I can prove. From one precipitation I had 5663 gr. of dried Ag Cl, which, according to calculation, would yield 4262 gr. of pure silver. I actually got 4250 gr., being a loss of 12 gr., possibly accounted for by the chloride having absorbed moisture between drying and weighing; or probably a small quantity of kaolin may have been mixed with the chloride. The process is also economical, NaOH costing about 4*d.* per lb., and sugar about $1\frac{1}{2}$*d.* per $\frac{1}{2}$ lb., which is sufficient to reduce considerably more than 1 lb. of Ag Cl to the metallic state, without the expense of building a furnace; also less the risk of a broken crucible, and possibly, the trouble of collecting the precious metal from the remains of a coke fire, which is anything but amusement. Those who prefer a crucible can obtain sufficient heat on an ordinary blacksmith's hearth, with a small coal fire.

(*m*) Put well-washed silver chloride into an iron ladle, with a little pure water above the chloride. The greater affinity of iron for chlorine determines its departure from the silver; and, after standing 24–30 hours, throw the contents of the ladle upon a filter, and wash thoroughly with pure water, to remove the soluble iron chloride; the residue will be pure silver in a minute state of division. This method is rarely employed, on account of the length of time required.

(*n*) Well-washed silver chloride (water does not dissolve a trace of it) is put into a stoneware pan with two or three times its weight of zinc, and the whole is covered with water rendered acid by sulphuric acid. As soon as they are in contact, these substances react upon each other; the sulphuric acid and the zinc decompose the water, the oxygen of which oxidises the zinc, which then combines with the acid, and forms zinc sulphate, a very soluble salt; the hydrogen transforms the chlorine of the silver into hydrochloric acid, which is also very soluble in water. Before filtering, wait until all the zinc is dissolved. The remaining silver is in impalpable powder, and cannot pass through the filter. Wash the silver thoroughly with pure water, and it may then be dissolved in pure nitric acid to form a pure silver nitrate. This process is seldom employed, as it is difficult to find zinc without lead, which will unite with and follow the silver in subsequent manipulations.

(*o*) The silver chloride, freed from foreign metallic salts by washing, is mixed with four times its own weight of crystallised soda carbonate, and half its weight of pulverised charcoal. Make into a homogeneous paste, dry thoroughly in an iron pan, and then place in a red-hot crucible. After fusion, the heat is raised, in order to allow the smallest globules to reach the bottom of the crucible. Should the crucible be moved at the time of the solidification, the silver will be of a very irregular shape. To obtain granulated silver, pour it in a small stream, and from a height, into a large volume of water.

(*p*) To recover silver from trimmings of untoned prints, procure an old iron bucket or pot, and place the cuttings in a few handfuls at a time, and apply a light to them, when they will quickly burn to ashes. As they burn down, keep adding the cuttings, which must be stirred up frequently with an iron rod, so as to completely reduce all the mass to fine ashes. Of course the burning must be done out of doors, owing to the dense smoke and disagreeable fumes. If in windy weather, place a piece of sheet iron partly over the bucket to prevent the ashes from blowing away. The fire will be a long time dying out. After the trimmings are reduced to ashes, the ashes can then be reduced to metallic silver in a crucible with equal quantities of soda carbonate and borax.

(*q*) The residues almost always exist as silver chloride. Wash by decantation, with plenty of water, in a capacious vessel which can be shaken, the mass —filter-paper and all—till free from copper, &c. Next drain off as much water as possible, and add strong ammonia, and after a time filter to get a clear solution. Place this in a wide-mouthed bottle, which fit with a cork. Through the cork pass two wires, to one of which attach a cathode of a strip of silver, and to the other an anode of lead. Lastly, connect a Daniell cell, and leave to itself for a day or two. The strip of silver will then be found studded with crystals of the reduced metal, while the lead will have a scale of lead chloride, some of which may have fallen to the bottom of the bottle. The ammonia is then shaken up, with the remaining undissolved residue, the lead is scraped, and the cell is recharged, when all is again ready to proceed for another two or three days. It is obvious that a bag of the washed residues can be suspended in the electrolytic bath. It is not a process to be recommended if rapidity is an object; but this is often of no consideration whatever. I do not recommend it for large quantities, though under certain circumstances it might answer even then; but for small quantities, such as pints or quarts, I certainly do, and claim for it the following advantages:—First and greatest, Less expenditure of superintending time and trouble than any other. The time expended in preparing the ammoniacal solution is but a few minutes. That expended in charging the cell is about the same, and besides these there is absolutely nothing to do beyond occasionally scraping the lead anode and collecting the silver crystals, after the easily fitted up and simple apparatus necessary has been procured. Second, Small cost of apparatus and materials. These consumed are zinc, copper sulphate, and lead. The ammonia will do over and over again, for the cork prevents its dissipation, and the loss in manipulation need be very small. Third, There is less mess and disagreeable work than any other method I know of. Fourth, The silver is obtained in a convenient form for future use, which is usually to prepare the reagent, silver nitrate. I have tried the method of reducing by means of zinc, but found these disadvantages and difficulties. First, It is not easy to ascertain when all the chloride is reduced. Second, Washing the metallic silver powder free from zinc chloride is a matter which takes a very considerable time. Third, The process is messy and disagreeable. Fourth, The reduced metal cannot be very pure, for ordinary zinc always contains a little lead, which would remain with the silver. I have also tried reduction by means of glucose, though not very thoroughly, finding it take time and trouble. The process of reduction with soda carbonate in a crucible is the worst of all in my estimation for small quantities. The time is greater than any others, and the heating of the crucible without special apparatus is most troublesome, to say nothing of the fuel consumed. Moreover, whatever others may find, I have always observed numerous little beads of silver scattered in a most aggravating manner all over the pot, which it is impossible to collect. I may mention that by the electrolytic method described, every trace of silver leaves the solution after a time, as may be proved by neutralising with an acid. One word more. It might be worth while dipping the ends of exposed iron into melted paraffin wax before placing in the electric bath.—(L. S. Powell.)

(*r*) A process invented by Stockmuir and Fleischmann and worked out by them in the chemical laboratory of the Bavarian Industrial Museum, is exceedingly simple, and is employed in many establishments. In order to remove silver from a potassium cyanide silver solution, it is only necessary to allow a clean piece of plate zinc to remain in the liquid for two days; even better results are obtained by the use of iron conjointly with the zinc. In the first case, the silver often adheres firmly to the zinc, whilst in the second it always separates out as a powder. It is then only necessary to wash the precipitated powder which usually contains copper (since spent silver solutions always contain copper), dry it, and then dissolve it in hot concentrated sulphuric acid, water being added, and the dissolved silver is precipitated by strips of copper. The silver thus obtained is perfectly pure. If the amount of copper present is only small, it can usually be removed by fusing the precipitated powder with a little nitre and borax.

In this way a spent silver bath was found to contain per litre

First experiment ..	1·5706 grm.
Second „ ..	1·5694
Mean	1·5700

The presence of silver could not be qualitatively ascertained in the residual liquor.

(*s*) After soaking the prints for 5 minutes in water made slightly acid by acetic acid, remove them to another dish, and add to the water from which you have just taken them about a teaspoonful of salt; stir it rapidly for a moment with the hand, when it becomes as white and thick as milk. This solution is then poured into a common wooden pail, which will hold enough water for the first washing of a hundred prints, and the next day, when ready to tone again, you will find that the solution has become perfectly clear, and in the bottom of the pail is a clear white sediment—pure silver chloride. Then pour off the water to within an inch of the bottom, and the pail is ready to be filled again.

On adding salt to the second water in which you washed the prints, there is hardly a trace of silver, and it is not worth saving. About once a month, pour the settlings from the pail through a fine cloth to filter it, and throw the cloth and contents into the silver paper clippings. In this way you will save more than half the silver used in making the print.—(A. C. Hopkins.)

(*t*) To separate silver bromide from waste emulsion, Scola recommends that 2–3 per cent. of sulphuric acid should be added, and the mixture should be boiled for some minutes, after which the bromide settles rapidly to the bottom of the vessel. It is now washed and dried, when it is ready to be cast into sticks for use in the battery about to be described.

The battery in which the reduction is effected is constructed on precisely the same principles as the silver chloride battery of Warren de la Rue, and one form of this, as is well known, consists of a rod of amalgamated zinc immersed in acidulated water, and opposed to a similar rod of fused silver chloride, a platinum wire being embedded in this latter to serve as a conducting terminal. When the plates of the battery are connected by a conducting circuit, the silver chloride becomes reduced to the condition of metallic silver, while the chlorine unites with some of the zinc to form zinc chloride.

If the negative plate of the battery is made of fused silver bromide, reduction takes place quite readily when the terminals are united; and when the battery is exhausted, it is merely necessary to fuse the resulting spongy silver in order to obtain it in a convenient condition for use in making a fresh supply of nitrate, while the whole of the bromine takes the form of zinc bromide, and remains in solution.

(*u*) Those who are familiar with gelatine dry plates must be aware of the large amount of undeveloped silver bromide film there is left on the plate after the development of the exposed image. For the purpose of dissolving the unused silver bromide and clearing the negative, it is immersed in a bath of soda hyposulphite. The bath, in the course of time, naturally becomes highly charged with the dissolved silver bromide, and many processes have been devised for recovering the waste silver therefrom.

One of the most simple is to pour into the hypo bath a saturated solution of potash sulphide, which immediately throws down the silver in the form of a black, flaky precipitate.

The principal objection to this process is the disagreeable smell of sulphuretted hydrogen gas given off, which is especially annoying when large quantities are used. The gas also does damage by injuring chemicals, sensitive plates, and paper within its reach. Dr. Legrange, a German chemist, recommended the use of a solution of ferrous oxalate, but as this is expensive its use has not become general. Quite recently Dr. F. Stolz, editor of the *Wochenblatt*, has followed out Legrange's idea by suggesting the use of the waste ferrous oxalate or pyro developer for precipitating the silver; a plan which is of practical use to the photographer and amateur. The precipitation of the silver is slower by this process than with the potash sulphide, but it possesses the advantage of utilising the waste developer, which is usually thrown down the sink.

After the old hypo bath has been poured into a stone jar or any old vessel the waste developer is mixed with it from time to time after it is used. Repeated pourings of the developer will, after a time, precipitate all the silver.

When all the silver has been apparently thrown down, a little of the clear liquid at the top is taken out in a test tube and tested with a solution of potash sulphide; if no precipitate occurs, all the clear liquid above the precipitate in the bottom of the jar may be decanted off, aud the next saturated solution of old hypo may be poured in and treated with the waste developer.

(*v*) The following is the course we advise for the adoption of the user of dry plates on a moderate scale, who is not averse to the reduction of his expenses by saving his silver waste:—Obtain a two-gallon glass jar having a loosely fitting cover, and about 4 in. from the bottom drill a hole in the side. This hole is then fitted with a wooden plug, or, what is better, a small tap, which is retained in place by screwed nut, aided by rubber washers. This jar is placed on a shelf in a garden or outside of a window; at any rate, in some place with which there is direct open-air communication. This is rendered necessary on account of the offensive smell emitted at a subsequent stage. Into this the waste fixing solutions are poured, and when the jar is nearly full, a small portion of a solution of potassium sulphide (sulphuret of potash or liver of sulphur) is poured in and mixed with the solution by stirring with a wooden or glass slab. Instantly there is a dense deposition of silver sulphide in the form of a dark mass. Precisely how much of the sulphuret ought to be added can be determined only by experiment. After the precipitate descends a little, if the addition of two or three drops of the sulphuret is not seen to produce a further precipitate, then has enough been added; but if this addition causes further blackness, it must be continued until all the silver is found to be converted into sulphide. It is advisable that no more be added than suffices to effect this end. Owing to the slowness with which the precipitation takes place, it may, in many cases, be expedient to have in use two such jars as that described. After the precipitate has settled down to below the level of the hole or tap in the side of the jar, the supernatant liquid must be run off through this aperture. Upon replacing the plug, water may be added to wash the silver sulphide which is insoluble in water. In this case the deposition will take place more quickly than before. Having obtained the silver sulphide as a dark pasty mass, it can either be placed in the hands of a professional metallurgist or reducer, who will most willingly either purchase it at full value, or fuse it into a button of metallic silver; or, secondly, it can be converted into silver nitrate by the addition of nitric acid, in which it readily dissolves; or, thirdly, it may be mixed with a flux composed of soda carbonate, 7 oz.; potash carbonate, 7 oz.; potash nitrate, 2 oz. Mixing this with the silver in equal proportions, placing in a crucible, and then fusing in a furnace, this gives a button of pure silver. The silver nitrate obtained by the second operation is not sufficiently pure for some purposes, but, of course, it may be easily purified. The following is a pretty experiment, and one which is also useful, inasmuch as it reduces the sulphide very quickly. Having cut a hollow in a block of wood, place in it a mixture composed as follows:—Sulphur, 2 parts; nitre, 4 parts; fine sawdust, 2 parts; with an equal volume of silver sulphide. Apply a lighted match to this, and deflagration will take place with great rapidity, and at the close, in a few seconds, the silver will be found at the bottom of the cavity as a beautiful white lump of shining metal.—(*Photo. Times.*)

Tin.—(*a*) The tin-clippings are put into a drum, consisting of stout copper-sheeting, and provided with holes $\frac{3}{8}$ in. diameter and 2 in. apart. It holds about 1000 lb. of clippings. It is first made to rotate in an acid bath, in which the tin is separated from the iron: then, by means of a crane, it is lifted into a water-bath, thence into a potash chlorate bath, and, finally, once more into a water-bath. In the first bath the drum rotates, according to the quantity of free acid, 5–50 minutes; in the others, which are only intended to wash away the acid, 5 minutes in each. The work of filling and passing the drum through the four baths, and emptying it, takes 70 minutes, and as a drum holds 1000 lb., 4½ tons of tin waste may easily be worked up in a working day of 10 hours.

In the acid bath about 5 per cent. of iron are dissolved beside the tin. This solution having been passed into suitable vessels, the lead is first separated, whereupon, by the insertion of zinc plates, pure tin is precipitated. The latter is obtained partly in well developed crystals, but mostly in a flocculent state. After having been well washed in water, it can be melted in an iron vessel, and cast in blocks for sale. Since, by the precipitation of the tin, zinc is dissolved (one part of zinc precipitates about two parts of tin), there is finally obtained a solution of zinc and sulphate of iron, which may be used for preserving wood from rot, for disinfecting, or in the preparation of various paints. The waste freed from tin is packed into casks, and sent to iron-works. All the work may be done by six men. The outlay for acids and zinc amounts to about 3*l.* 5*s.* per ton. The waste is sold at 8–12*s.* per ton.—(A. Otto.)

(*b*) It is not possible to obtain a complete separation of the iron and tin by proceeding according to the various methods which depend upon bringing the scrap to the melting-point of tin, which is then removed in the molten state by mechanical means, such as revolving the scrap in a drum with sand, or by use of a centrifugal machine. The iron which is left contains so much tin as to be of little value for working up in the furnace. The salts of tin obtained by treating the scrap with acid solvents are also too much contaminated with iron to render an acid extraction process advisable. Better results, however, should be obtained with Reinecker's process, which depends upon the power which caustic alkali has of dissolving tin when an oxidising agent is present. According to this process, the scrap is cut up into small fragments, treated in revolving drums with caustic soda for the removal of grease, and thence transferred to other drums, to be acted upon by a solution of lead oxide in caustic soda. The reaction which occurs may be expressed by the equation: $Sn + 2NaOH + 2PbO = Na_2SnO_3 + 2Pb + H_2O$, and since, to a great extent, this is prevented from taking place by atmospheric carbonic acid, Reinecker has devised a suitable apparatus for the purpose. The lye containing soda stannate is separated from the finely divided lead, the former to be worked up in the most convenient manner, the latter to be oxidised and employed in subsequent operations.—(Dr. Czimatis.)

(*c*) Owing to the vast accumulation of tin scrap in canister, button, and other manufactories where tinned iron plate is extensively employed, considerable attention has been devoted to the utilisation of the same, chiefly with a view to the recovery of the tin, either in the metallic form or that of one of the various salts of tin used in commerce.

It would be interesting and amusing, although not instructive to an equal degree, to glance at the various methods, patent or otherwise, which have been suggested from time to time to effect this purpose. The separate actions of acids, alkalies, and chlorine gas have been utilised; friction and fusion have been resorted to; and more recently electricity has been pressed into service.

Of these methods I am only aware of three which have been employed on any large scale, viz. dissolving in a mixture of hydrochloric and nitric acids, and subsequent precipitation of tin by metallic zinc; treatment with caustic soda and litharge, forming soda stannate; and the formation of tin tetrachloride by the action of dry chlorine gas.

The last-named process is worthy of special mention. It has been described by Prof. Lunge in his report of the chemical section of the Swiss National Exhibition, held in Zürich in 1883.

Some time ago I was requested to recommend some practical method for the utilisation of these tin cuttings, in a district where they could be collected in large quantities. After reading all the literature at my disposal relating to the subject, I was induced to make some experiments, and amongst others, actuated by a knowledge of certain electrolytic processes employed for the precipitation of metals from their ores, I tried the effect of a current of electricity in passing through an acid solution in which a quantity of cuttings were suspended forming the anode, a copper plate serving as cathode. These experiments proved that not only is tin dissolved at the anode, but that it is also deposited in a pure form at the cathode, very soon after the commencement of the action. After continuing these experiments, and making the necessary calculations, I came to the conclusion that this might form the basis of a practical method for the recovery of tin from tin scrap on a large scale.

I recommended that a trial should be made of this process; this was undertaken; the ceremony of obtaining a patent was duly observed, and I was intrusted with the supervision of the erection of the plant, an account of which, and of the results obtained therefrom, I now give in a brief form.

At least four English patents have been granted for the same object, effected by very similar means; still, as there are important differences in the process about to be described, and especially as, to the best of my knowledge, it was under my direction that the first plant was erected for the employment of an electrolytic method on any large scale, I venture to hope that the following details may be of interest.

The cuttings with which we had to deal varied considerably in value. Some of the thicker ones contained little more than 3 per cent. of tin, while some of the thinner kinds contained 8–9 per cent. I considered 5 per cent. as about an average. The quantity obtainable was calculated at about 6 tons per week, and the plant was designed to accommodate that quantity, charging twice a day. The iron was designed to be converted into sulphate, a large quantity of which could be disposed of at a high price; the remainder was to be converted into "iron mordant"; the tin was to be converted into stannons chloride, and other salts of tin employed as mordants, and largely used by the dyers of that neighbourhood.

No doubt could exist as to the best source for the production of such a strong current as that required, the difficulty was to select the dynamo machine which would be most suitable for the purpose. The machiues manufactured by Siemens and Halske of Berlin had been very highly spoken of as yielding good results in the precipitation of copper on a large scale at Oker in Germany. This firm was appealed to, and one of their small machines was recommended, which, although calculated to perform only about one-half the work required, was deemed sufficient to commence with. This machine is numbered C_{18}, and it is stated to give a current of 240 ampères with an electromotive force of 15 volts, aud an expenditure of 7 horse-power. (Of course this is considerably higher than the calculated power required.)

From the given capacity of the machine it is easy to calculate that the best result would be obtained, without danger of over-heating the machine, by arranging the total resistance to be equal to $\frac{1}{16}$ ohm. As the subject of the resistance of various liquids to the passage of the electric current has been so imperfectly investigated, and data respecting other factors being likewise unobtainable, it was impossible to determine the best form, number, and arrangement of baths for the purpose in question. The best plan was evidently to make the resistance of each bath as little as possible, consistent with facility of working, and then to arrange them parallel, or in series, or both, so as to include the resistance mentioned above. Eight baths were decided upon. These were made of wood, lined with rubber, and each had the following internal dimensions. Length 150 cm., breadth 70 cm., depth 100 cm. The thickness of the wood was 5 cm., that of the rubber 3-4 mm. Each four baths were formed by the division of one large tank, 3 m. by 1½ m., and the two tanks were firmly secured by iron bolts running from side to side. Placed longitudinally they occupied exactly the breadth of the building, and they were fixed at the end of the same, at an elevation of one metre from the ground. In front was a platform, at one side of which was a door for the admission of the cuttings, after being washed and packed. The dynamo was situated in the engine room just behind the baths, and communication was made by two copper cables passing through a hole in the wall. At either side wall, and on a level with the baths, was a dissolving tank capable of accommodating half the cuttings after the removal of the tin. A little farther on, and nearly on a level with the ground, were the evaporating down tanks. The crystallising tanks were situated beneath the ground level, so that the solution could be run off from one stage to another without any pumping arrangemeut.

The anodes were composed of the tin scrap. Baskets were obtained to pack the cuttings iu. These, at first, were made of wicker-work, but as they were too flexible, and soon rotted by the action of the acid, their place was supplied by strong wooden baskets, whose sides were formed of stout upright wooden bars, 2 cm. thick, with spaces between them sufficient to allow the solution to circulate freely, while preventing the exit of the scrap. The internal dimensions of the baskets were:—Length, 120 cm.; breadth, 30 cm.; depth, 85 cm. Great care was required in packing the scrap, because, if it were packed too closely, the metallic surfaces thereby united, and preventing the circulation of the electrolyte between them, necessarily retained their coating of tin. These baskets held 60–70 kilo. of the scrap, the 8 being capable of accommodating about half the total quantity required. Long and narrow strips of the same material were employed to complete the communication with the conductor. As the resistance of iron to the current is comparatively great, a large number of these were required to prevent excessive heating. At one end they were soldered together, and connected with the copper conductor by means of binding screws; the other extremities were distributed throughout the scrap.

Copper plates were employed as cathodes. These had a thickness of 1½ mm., were 120 cm. long, and 95 cm. in breadth. There were 16 in all, two for each bath, placed one on either side of the baskets. To keep these thin plates of copper as plane as possible, each was surrounded by a framework of copper rod of square section. They were coated with tin to prevent corrosion, as well as to avoid solution by any accidental reversal of the current. These plates rested in grooves at the sides of the tanks, placed at a distance of 10 cm. from the sides of the baskets. They were provided, as also were the baskets, with rubber rollers extending to the sides of the baths, enabling them to be raised out of the same with ease, and without injury to the rubber coating.

Dilute sulphuric acid formed the electrolyte. This was employed, not only on account of its comparatively small resistance to the current, but also because it was convenient to turn the solution into the iron sulphate tanks, as soon as it became saturated with that salt, and all the tin had been precipitated from it. Commercial acid of 60° B. was diluted with 9 volumes of water.

Above the tanks was a pulley arrangement for raising the baskets and plates out of the baths as required; there was also an arrangement of levers and eccentrics constructed, whereby the baskets were kept in gentle motion in the baths, thus exciting circulation in the liquid, and tending to prevent polarisation. The horizontal axis upon which the eccentrics were disposed made about two revolutions per minute, thereby raising the baskets a distance of about 5 cm. Levers were fulcrumed into the wall; these passed over the eccentrics, and at their extremities ropes were fixed communicating with the baskets.

The current was conducted by thick copper wires of several plies. Although already coated, they were enclosed in rubber tubing as an additional protection.

One of Crompton's indicators, registering up to 250 ampères, was obtained for measuring the strength of the current, and detecting flaws or breakages in the same. Some such instrument is invaluable for such work, and this proved very reliable.

The arrangement of the plant having been detailed, it remains to give the results of the working of the same. The critical point had been arrived at; the working capacity of the structure was to be determined; that which calculation could not indicate was about to be demonstrated. Acting in accordance with the principle, "Aspire high," the baths were first arranged in *series*. The connections being complete, the engine of 8 horse-power was set in motion; the dynamo increased rapidly in speed, while the needle of the indicator followed tremulously until it stood vacillating within a few degrees of 240 ampères, the dynamo then making about 900 revolutions per minute. Thus the most economical conditions of working had luckily been hit upon; the machine bore the current bravely, showing no signs of over-heating.

The tin deposited was at first of a spongy nature, owing to the great acidity of the bath. Soon, however, it began to be precipitated in a more dense, extremely fine, granular, and partially crystalline state, which indeed was preferable, as it fell to the bottom of the bath, and was not in danger of forming a communication with the anode. I will not say that the tin was "chemically pure," but it was purer than commercial tin, and, when thoroughly washed, contained no trace of iron. It fused readily, and almost completely, and that without any addition, provided it had previously been thoroughly washed and dried. The rapidity with which it dissolved in hydrochloric acid was not to be compared to the slow action of that liquid upon granulated tin, and this rendered it peculiarly suitable for the production of stannous chloride.

From the data already given, the theoretical amount of tin deposited can readily be calculated. The electro-chemical equivalent of tin as a dyad, compared with silver is $\frac{117 \cdot 8 \div 2}{107 \cdot 66} = 0 \cdot 546$, and this is equivalent to the precipitation of $67 \cdot 65 \times 0 \cdot 546 = 36 \cdot 94$ mgm. of tin per minute per ampère. For 240 ampères, working through 8 baths arranged in series, we obtain a total precipitate of $\frac{36 \cdot 94 \times 240 \times 8 \times 60}{1,000,000} = 4 \cdot 25$ kilo. per hour. As a matter of fact, little more than half this quantity was obtained, the discrepancy being due to part of the current being absorbed in dissolving the iron as well as the tin, as soon as the former began to get bare. This, together with the natural solution of the iron in the acid, led to the rapid accumulation of sulphate of iron in the baths. The acid here employed took about seven weeks to become saturated. On analysis, the baths were found to vary in a very remarkable manner, first one and then another containing the largest quantity of iron. The tin, on the contrary, remained very constant in amount, both in the individual baths and in the total, the average being 1·5 grm. per litre. Pure tin was deposited until the acid was saturated and no more tin was present in solution; then iron hydrate began to form. This might be avoided for a time by the addition of more acid, but it was better to run the liquid into the "green vitriol" tanks, and add fresh solution. It was not at all necessary to continue the action of the current until all the tin had been removed; in fact, after a certain time the action on the iron was even stronger than on the tin. It was found in practice that after the passage of the current for the space of 5–6 hours the quantity of scrap referred to was sufficiently free from tin to be dissolved in the iron sulphate tanks with the greatest ease; the tin remaining unacted upon in the presence of the large excess of iron always provided for, and it was not difficult to recover that tin, and utilise it with the rest.

Cost of plant and expense of working of course would depend upon the neighbourhood fixed upon, and other circumstances; but, in any case, they would be little compared with the value of the tin capable of being recovered. I think I have given sufficient details for any one to be able to calculate approximately their amount for any particular locality. Generally, this scrap is obtained for a mere nominal sum, frequently just for the expense of transport. One stoker and two or three labourers would be quite sufficient to work three tons per week, using one of the small dynamo machines manufactured by Siemens Bros. The 3 cwt. of metallic tin obtained therefrom, at 3*l.* 18*s.* per cwt., will compare favourably with the cost of fuel necessary to maintain the production of 7 or 8 horse-power, wages of workmen, interest on the plant, and occasional repairs. If it were worked on a larger scale, and the tin and iron further worked up into salts, as in the instance detailed, the profits would be increased in a much greater ratio. When we consider that in Paris alone 3000 tons of this scrap are produced annually, it is no unimportant matter to determine the best method of utilising it.

In addition to the consideration of economy, this method possesses advantages which are well worthy of attention, especially where iron sulphate and "iron mordant" are marketable products. As has been observed, the tin is precipitated in a pure form, and in a state of fine division. It may, therefore, be either fused and sold in the metallic form, or it may be converted into stannous chloride, or other salts, for which it is exceedingly well suited, owing to the ease with which it is dissolved. In the process in which the scrap is acted on by chlorine gas, no choice exists as to the form in which the tin shall be sent to the market, tetrachloride being the constant product. The same remark applies to the method where caustic soda and litharge are employed, and in other respects this latter method has little to recommend it, judging from my own observations. The other process which I mentioned is also unsatisfactory. In employing a mixture of hydrochloric and nitric acids, considerably more iron than tin is dissolved, and when the tin is precipitated by metallic zinc, the contamination of the iron chloride with zinc chloride renders it of little value. I do not claim perfection for the method I have advocated. It is capable, however, of considerable modification. A better electrolyte could doubtless be found; probably a solution of stannous sulphate would be the best. I think, however, I have proved that this process is practical, simple, and economical, and further, that it presents the additional advantages of purity of product and variety of utilisation, thus rendering it well worthy of a wider application.

The cost of the tin scrap at the locality spoken of was only 2 francs per ton.—(Dr. J. A. Smith.)

RUBBER.

Solvents. — Benzine is an excellent solvent for caoutchouc and gutta-percha. Caoutchouc or rubber, may also be dissolved in ether, carbon sulphide, naphtha, spirit of turpentine, and chloroform.

Solutions.—(*a*) A mixture of 6 parts absolute alcohol with 100 of carbon sulphide; the latter is the real solvent, the alcohol has an indirect action. The quantity of solvent required depends on the consistency of solution required; if moderate heat is used, and the mixture is shaken, the whole dissolves, but a better solution is obtained for adhesive properties by using a large quantity of solvent, not shaking, but drawing off the clear glazy liquid. (*b*) For a small quantity, place 1 fl. dr. sulphuric acid and the same quantity of water into a phial bottle, and well shake together. Great heat is evolved. Allow to stand till cool; then add 2 fl. oz. spirits of turpentine, and shake well. Great heat will again be evolved, and the colour changed to deep cinnamon. Allow to stand for 24 hours, after which a strong dark sediment will have settled at the bottom of the bottle. Pour off the clear liquor into another bottle, and add 1½ dr. common rubber cut up into fine shreds, and then place it uncorked over a very gentle heat, and allow to boil slowly for 5 hours. At the end of that time the rubber should be perfectly dissolved. It can be concentrated by longer boiling, or thinned by the addition of more turpentine.

Piecing.—Make a long bevel on the ends to be joined with a sharp rough-edged knife and water, scrape the bevels rough with the edge of the knife, and when quite dry, give each a coat of rubber solution: say 1 oz. rubber not vulcanised to 5 oz. turpentine. When the first coat is dry, give it another, and when that is dry, put the two ends together.

EBONITE AND VULCANITE.—The only difference between these two articles is in the colouring materials used. These terms are applied to a compound of rubber and sulphur, exactly the same as the common elastic bands, the only difference being in the time and heat required to vulcanise or harden the compound. To prepare it as sold in the form of combs, the rubber is put into a masticator along with a proper proportion of sulphur, and when thoroughly mixed a sufficient quantity is put into a mould of the right shape made of plaster of Paris, or other material which will not combine with sulphur, and exposed in a steam boiler to a heat of 315° F., and a pressure of about 12 lb. to the inch for 2 hours. It is then removed from the mould, and finished, and polished exactly in the same manner as ivory. The application of heat as above without a steam pressure is sufficient to vulcanise or harden the compound, but the result is not always so satisfactory, as the material is liable to be porous if not compressed whilst hardening. Gutta-percha may be treated in exactly the same manner as rubber, and cannot be distinguished from it, but is rather more troublesome to work. The vulcanite may be turned or carved in the same way as ivory, with the advantage that it may be moulded to the required form without the great waste which attends ivory carving. It is also much less liable to fracture. The smaller the proportions of sulphur in the rubber, and the lower the temperature used, the softer and more elastic will be the rubber. About 10 or 15 per cent. of sulphur, and a temperature of 270°–275° F. for 4 hours, will make an elastic rubber; 30 per cent. of sulphur and a temperature of 315° F. for two hours will make a hard vulcanite like ivory.

The reader is also referred to the article on "Indiarubber Manufactures" in Spon's 'Encyclopædia.'

RUST.

To prevent Rusting.—(*a*) Boiled linseed oil will keep polished tools from rusting if it is allowed to dry on them. Common sperm oil will prevent them from rusting for a short period. A coat of copal varnish is frequently applied to polished tools exposed to the weather. Woollen materials are the best for wrappers for metals.

(*b*) Iron and steel goods of all descriptions are kept free from rust by the following:—Dissolve ½ oz. camphor in 1 lb. lard, take off the scum, and mix as much black-lead as will give the mixture an iron colour. Iron and steel and machinery of all kinds, rubbed over with this mixture, and left with it on for 24 hours, and then rubbed with a linen cloth, will keep clean for months. If the machinery is for exportation, it should be kept thickly coated with this during the voyage.

Anti-rust Varnish.—Take the first three ingredients in a pounded condition, and digest them by a regular heat till melted, then add the turpentine very gradually, stirring all the while. Rosin, 120 parts; sandarac, 180; gum lac, 60; essence of turpentine, 120. The mixture should be digested until solution, then add rectified alcohol, 180 parts. Filter through fine cloth or thick bibulous papers, and preserve in well-stoppered bottles or cases.

Removing Rust from Steel.—Immerse the article to be cleaned for a few minutes until all dirt and rust is taken off, in a strong solution of potassium cyanide, say about ½ oz. in a wineglassful of water; take out and clean it with a toothbrush, with some paste composed of potassium cyanide, Castile soap, whiting, and water; these last are mixed in a paste about the consistence of thick cream.

INDEX.

Acid, Cleaning Metals by, 250
—— frosting, 101
—— marble sculpture by, 121
—— pouring frame, 243
—— white, 101
Acid proof cement, 24
Ageing liquor, 45
Alabaster, cleansing, 31
Albert transfer paper, 238
Alcohol barrels, 1
Alloys, 1–5
—— aluminium bronze, 1
—— artificial gold, 4
—— Babbitt's metal, 1
—— brass, 2
—— Britannia metal, 3
—— bronze, 3
—— bullet metal, 3
—— Chinese silver, 3
—— cock metal, 3
—— cymbal metal, 3
—— German silver, 3
—— gun metal, 4
—— imitation silver, 4
—— impressions, 4
—— journal boxes, 4
—— medal, 4
—— muntz metal, 4
—— organ pipe metal, 4
—— ormolu, 4
—— pinchbeck, 4
—— queen's metal, 4
—— rivet metal, 4
—— speculum metal, 4
—— statuary metal, 5
—— stereotype metal, 5
—— tinning metal, 5
—— tombac, 5
—— tutania, 5
—— type metal, 5
—— white metal, 5
Aluminium bronze. 1
Amalgamating salt, 267, 363
Amalgamation gilding, 273
Amber dyeing silk, 52
—— —— woollen, 55
—— mending, 6
—— working, 5
Ammonia paste, 52
Annealing glass, 98
Antimony deposits, 263
Aquafortis, 6
—— etching, 67
Aqua-regia, 6
Aquarium cements, 25
Aquatinta etching, 73
—— first lights, 74
—— general instructions, 75
—— ground, 73
—— —— laying, 73
—— —— to etch on, 75
—— —— trying, 73
—— second lights, 74
—— stopping out the lights, 74
—— testing spirits, 73
—— third lights, 74
—— touching stuff, 74
Archerean battery, 259
Architectural cements, 25
Argentine, 355
Argentometer, 167
Armenian cement, 25
Artificial gold, 4
Ash vat, 55
Asphalt pavement, 148
Attrition metal, 1
Aurum musivum, 19
Autotypes, 228

Babbitt's Attrition Metal, 1
Badger tools, 133
Barrels, browning, 19
—— tightening, 1
Batteries, bringing into action, 258
—— charging, 257
—— galvanoplastic, 362
—— keeping in order, 258
—— plating, 257
—— porous cells, 259
Bending glass tubes, 98
Bismuth deposits, 263
Biting-in etching, 69, 73
Black crayons, 33
—— dyeing cotton, 45
—— —— silk, 49
—— —— woollen, 53
—— electrotypes, 18
—— glass, 131
—— liquor, 45
Blacking, 6
Bleaching books, 7
—— ivory, 6
—— lace, 7
—— paper, 7
—— prints, 7
—— silk, 8
—— wool, 8
Blue crayons, 33
—— dyeing cotton, 46
—— —— silk, 49

Blue dyeing woollen, 53
—— glass, 131
Boiler incrustations, 8
Boiling tallow, 21
Bone, polishing, 378
Bookbinder's paste, 30
Bookbinding, 8
—— casing, 11
—— cutting, 9
—— finishing, 12
—— headbanding, 11
—— lettering, 12
—— marbling, 14
—— ornamenting, 11
—— polishing edges, 13
—— pressing, 9
—— sewing, 9
—— tools, 8
—— without tools, 13
Books, bleaching, 7
Bordering etching plate, 69
—— wax, 66
Borders of drawings, 38
Brass, 2
—— bath, arranging, 265
—— —— correcting, 265
—— brightening, 2
—— bronzing, 16, 266
—— cleansing, 31
—— cold, for all metals, 264
—— colour of deposit, 265
—— colouring, 2
—— deposits, 263
—— for iron, 264
—— —— lead, 264
—— —— pewter, 264
—— —— tin, 264
—— —— zinc, 265
—— inlaid work, cleansing, 31
—— polishing, 380
—— silvering, 340
—— tinning, 354
—— wire, tinning, 356
—— zinc coating, 359
Brightening brass, 2
Britannia metal, 3
—— —— silvering, 341
Bromide plates, 212
Bronze, 3
—— antique, 266
—— black, 266
—— powders, 19
Bronzing brass, 16, 266
—— cardboard, 266
—— copper, 267
—— —— utensils, 17
—— electrotypes, 18
—— gas fittings, 18
—— gold size, 291
—— iron, 18, 267
—— medals, 268
—— paper, 18
—— plaster, 18, 268
—— powders, 19, 269
—— tin, 269
—— wood, 19, 269
—— zinc, 270
Brown crayons, 33
—— dyeing copper, 46
Brown dyeing silk, 50
—— —— woollen, 53
—— electrotypes, 18
—— glass, 131
Browning gunbarrels, 19
Brushes for water-colour printing, 141
—— marbling, 14
—— paint, 132
—— —— cleaning, 133
Buff dyeing cotton, 48
—— —— silk, 52
—— —— woollen, 55
Bullet metal, 3
Bunsen's battery, 259
Burnished gilding, 295
Burnishers, 373
Burnishing, 373
Buttons, artificial mother-of-pearl, 127
Buying drawing instruments, 36

CALLAUD BATTERY, 260
Cameo cutting, 20
Cameras, 154, 233
—— home-made, 155
—— twin lens, 183
Candles, composite, 23
—— diaphane, 24
—— dips, 22
—— making, 20–4
—— moulds, 23
—— ozokerit, 22
—— snuffless, 24
—— tallow, 20
—— transparent, 24
—— wicks, 22
Canvas painting, 133
Carbon printing, 223
—— prints, colouring, 230
Carbon pouring frame, 243
Cardboard bronzing, 266
Carmine crayons, 33
Casehardening iron, 114
Casing books, 11
Casks, tightening, 1
Cast iron, softening, 114
—— steel, tempering, 114
Catgut making, 24
Catherine wheels, 94
Ceilings, plastering, 118
Celluloid films coating, 174
Cements, 24–31
—— acid-proof, 24
—— aquarium, 25
—— architectural, 25
—— Armenian, 25
—— chemical, 25
—— Chinese, 25
—— cutlers', 25
—— elastic, 25
—— electrical, 25
—— engineers', 25
—— fire lutes, 26
—— fireproof, 25
—— glass to metal, 29
—— —— and wood, 30
—— glue, 26
—— gum, 28
—— impervious, 28
—— indianite, 28

Cements, iron pots and pans, 28
—— —— railings, 28
—— —— rust, 28
—— ivory, 29
—— jet, 29
—— jewellers', 25
—— leather, 29
—— London, 29
—— marble, 29, 125
—— mastic, 122
—— meerschaum, 29
—— metal and wood, 30
—— mother-of-pearl, 29
—— parchment paper, 30
—— paste, 30
—— plumbers', 30
—— prints, 30
—— rubber, 30
—— rust joints, 28
—— stonemasons', 30
—— turners', 30
—— using, 31
—— waterproof, 2
—— wood and glass, 30
—— —— cracks, 31
—— —— vessels, 31
Ceramic articles, metallising, 365
Chalk, lithographic, 58
Chamois dyeing silk, 52
Charcoal for gunpowder, 112
Chemical cement, 25
Chertier's copper, 85
Chinese cement, 25
—— fire, 87
—— silver, 3
Chipped glass, 98
Chisels, engraving, 63
—— tempering, 115
Claret dyeing cotton, 48
—— —— silk, 51
—— —— woollen, 54
Clarifying fat, 21
Cleansing alabaster, 31
—— brass, 31
—— —— inlaid work, 31
—— brushes, 133
—— copper, 31, 250
—— engravings, 31
—— glass, 98
—— hands, 32
—— hats, 32
—— inlaid work, 31
—— iron, 254
—— jewellery, 32
—— lead, 254
—— marble, 32, 124
—— metals, 32
—— —— by acid, 250
—— pearls, 32
—— photo. glasses, 164
—— pictures, 32
—— plate, 32
—— silver, 32, 255
—— steel, 32, 255
—— swords, 33
—— tin, 254
—— zinc, 255
Clock-dials, silvering, 341
Cobalt plating, 270
Cock metal, 3
Collodion-chloride paper, 205
—— clearing, 174
—— emulsions, 222
Colour harmony, 138
—— photography, 244
Coloured fires, 95
—— lights, 90
Colouring brass, 2
—— drawings, 39
—— tracings, 40
Colours for marbling, 14
—— graining, 103
Compasses, using, 37
Composite candles, 23
Concrete pavements, 149
Copper, bronzing, 267
—— Chertier's, 85
—— cleansing, 31, 250
—— engraving, 55
—— plate, 56
—— plating, 270
—— —— by dipping, 270
—— ——, galvanic, 271
—— salts, recovering, 394
—— silvering, 341
—— tinning, 354
—— transferring to stone from, 59
—— utensils, bronzing, 17
—— zinc coating, 359
Copying drawings at reduced scale, 43
—— photos., 198
Cotton dyeing, 45
—— spirits, 49
Crackers, 94
Crayons, 33
—— for drawing on glass, 34
Cream dyeing silk, 52
Crimson dyeing cotton, 48
—— —— silk, 51
—— —— woollen, 54
Crocus, 371
Crown glass, 102
Crystalline glass, 98
Cutlers' cement, 25
Cutlery, burnishing, 371
Cutting books, 9
—— cameos, 20
—— pencils, 35
—— stencil plates, 40
Cymbals, 3

DANIELL BATTERY, 260
Dark room, 150
—— —— developing without, 153
Darkening glass, 100
Desilvering, 351
Diamond writing ink, 101
Diaphane candles, 24
Dip candles, 22
Dipping copper, 250
Dividers, using, 37
Drabs, dyeing cotton, 47
—— —— silk, 50
—— —— woollen, 53
Drawing paper, silver prints on, 207
—— room fireworks, 93
Drawings, 34–35
—— board, 36

Drawings, borders, 38
—— buying instruments, 36
—— colouring, 39
—— colouring tracings, 40
—— compasses, using, 37
—— copying at reduced scale, 43
—— cutting pencils, 35
—— dividers, using, 37
—— erasing errors, 35
—— fastening on board, 35
—— finishing, 37
—— frame, 42
—— indelible pencil, 42
—— Indian ink, 39
—— lettering, 37
—— mounting, 42
—— —— on linen, 34
—— on glass, 100
—— —— —— crayons for, 34
—— —— stone, 58
—— wood, 64
—— paper, 34
—— parallel rule, using, 37
—— pen, using, 36
—— pencilling, 37
—— removing from board, 41
—— shading, 40
—— stencil plates, cutting, 40
—— —— —— using, 41
—— testing straight edge, 36
—— vegetable parchment, 42
Drilling glass, 100
Dry plates, rapid, 173
—— point etching, 70
Dyeing, 45–55
—— ageing liquor, 45
—— ash vat, 55
—— black liquor, 45
—— cotton, 45
—— —— spirits, 49
—— mordants, 45
—— pink mordant, 45
—— red mordant, 45
—— silk, 49
—— woollen, 53
—— —— spirits, 55
Dynamite, 129

Easel, 132
Ebonite, 407
Elastic cement, 25
—— glue, 27
Electrical current, 25
Electro-phototypy, 236
Electrotypes, black, 18
—— bronzing, 18
—— brown, 18
—— green, 18
Emery wheels, 372
Emulsions, photographic, 212, 222
Enamelled paper, 142
Enamelling slate, 125
Enamels, pottery, 386
Engineers' cement, 25
Engravers' lamp, 61
—— shade, 66
—— tools, 61
Engraving, aquatinta, 73
—— chisels, 63
Engraving copper, 55
—— gold, 56
—— gouges, 63
—— plugging wood, 65
—— proofs, 65
—— rosin ground, 75
—— silver, 56
—— steel, 59
—— —— cylinders, 61
—— stone, 57, 59
—— tint tools, 62
—— wood, 61
Engravings, cleansing, 31
—— mounting, 42
—— transferring to glass, 102
Erasing errors from drawings, 35
Etching, 65
—— aquafortis, 67
—— aquatinta, 73
—— biting-in, 69, 73
—— bordering plate, 69
—— —— wax, 66
—— cleaning off, 70
—— colour for glass, 131
—— dabber, 65
—— drawing, 72
—— dry point, 70
—— from nature, 78
—— general instructions, 71
—— glass, 101
—— ground, 65
—— Hamerton's brush process 75
—— —— negative process, 76
—— —— positive process, 77
—— hand-rest, 66
—— heating plate for ground, 67
—— in stone, 58
—— iron, 79
—— lamp, 66
—— laying ground, 72
—— needles, 69
—— oil rubber, 65
—— process avoiding stopping-out, 71
—— re-biting, 70
—— re-etching, 71
—— rosin ground, 75
—— rottenstone, 66
—— second biting, 70
—— shade, 66
—— smoking plate, 68
—— soft ground, 72
—— steel, 78
—— stippling, 78
—— stopping-out varnish, 66
—— taper, 66
—— testing ground, 67
—— tracing, 67
—— —— paper, 67
—— transferring, 68
—— —— paper, 67
—— turpentine varnish, 66

Fading Photos., 192
Fat boiling, 21
—— clarifying, 21
—— rendering, 20
Fawn dyeing cotton, 47
—— —— silk, 50
—— —— woollen, 53

Files, softening, 114
Finishing books, 12
Fire balloons, 93
—— lutes, 26
—— proof cement, 25
—— showers, 94
Fireworks, 79
—— brilliant fire, 87
—— Catherine wheels, 94
—— Chertier's copper, 85
—— Chinese fire, 87
—— coloured fires, 95
—— —— lights, 90
—— common fire, 87
—— crackers, 94
—— drawing-room, 93
—— fire balloons, 93
—— gerbes, 87
—— golden rain, 83, 85
—— jets, 87
—— lances, 89
—— lightning paper, 93
—— Pharaoh's serpents, 95
—— pin wheels, 94
—— portfires, 85
—— pyrotechnic mixtures, 95
—— quickmatch, 87, 93
—— rockets, 79
—— Roman candles, 86
—— —— —— stars, 86
—— saltpetre for, 94
—— serpents, 94
—— showers of fire, 94
—— silver rain, 85
—— squibs, 94
—— stars, 82
—— strontia nitrate, 85
—— touchpaper, 87
—— tourbillons, 90
Flashlight photos., 190
Flock gold size, 292
Floorcloth, 96
Floors, pugging, 118
Fluxes, 96, 386
Focus, photographic, 163
Frame, drawing, 42
—— for pouring acids, 243
French polishes, 376
—— polishing, 375
Fresco painting, 129
Fretwork polishing, 378
Frosted silver, 337
Frosting acid, 101
—— glass, 102
Fulminates, gold, 97
—— mercury, 97
—— platinum, 98
—— silver, 98
—— —— and ammonia, 98
Furniture creams, 377
—— pastes, 376
Fusible metal moulds, 366

GALVANISING IRON, 359
Galvanoplasm, 361
Galvanoplastic baths, 361
—— batteries, 362
Gas fittings, bronzing, 18
Gelatine bromide plates, 212
Gelatine chloride paper, 174
—— emulsion, coating paper with, 203
—— moulds, 367
—— plates, photo-micrography on, 231
Gerbes, 87
German silver, 3
—— —— polishing, 380
Ghost pictures, 195
Gilding, 273
—— amalgamation, 273
—— baths, 277
—— —— hot, 283
—— burnished, 293, 295
—— cement, 290
—— cold, with rag, 275
—— colouring, 284
—— copper bars for rolling, 277
—— dead lustre, 276, 285, 363
—— dipping, 277
—— flowers, 287
—— glass, 287, 295
—— gold powder for, 292
—— graining, 289
—— Grecian, 275
—— green and white, 284
—— in colours, 275
—— insects, 287
—— japanners', 293
—— leather, 297
—— letters, 303
—— oil, on wood, 293
—— ormolu, 287
—— paint, 297
—— paper hangings, 297
—— partly dead lustre, 276
—— picture frames, 298
—— pink, 284
—— porcelain, 287, 295
—— pottery, 303
—— red, 284
—— resists, 290
—— signs, 303
—— silver, 288
—— steel, 288
—— watch parts, 289
—— water, 293
—— writings, 305
—— yellow, 285
—— zinc, 305
Gilt articles, removing gold from, 305
Glass and wood cement, 30
—— annealing, 98
—— bending tubes, 98
—— cement, 29
—— chipped, 98
—— cleaning, 98
—— crayons for drawing on, 34
—— crystalline, 98
—— cutting board, 202
—— darkening, 100
—— drawing on, 100
—— drilling, 100
—— etching, 101
—— frame, photographic, 164
—— frosting, 102
—— gilding, 287, 295
—— painting, 130
—— platinising, 327
—— silvering, 341

Glass, stencilling on, 102
—— transferring engravings to, 102
—— windows, 102
Glaze wheels, 372
Glazes, pottery, 391
Glazing oil paintings, 135
Glue, 26
—— elastic, 27
—— liquid, 27
—— marine, 28
—— melting, 27
—— mouth, 28
—— portable, 28
Gold amalgam, 273
—— artificial, 4
—— baths, 370
—— bronze powders, 19
—— dissolving, 305
—— —— in aqua-regia, 283
—— engraving, 56
—— fulminate, 97
—— powder for gilding, 292
—— recovering, 394
—— removing from gilt articles, 305
—— salts, making, 176
—— size, 135, 291
Golden rain, 83, 85
Gongs, 3
Gouges, engraving, 63
Graining, 103
—— colours, 103
—— gilding, 289
—— grounds, 103
—— marbling, 109
—— over graining, 107
—— powders, 289
—— roller, 107
—— styles, 106
Graphite, metallising, 364
Gravers, 61
—— holding, 64
—— preparing, 63
Green crayons, 34
—— dyeing cotton 47
—— —— silk, 50
—— —— woollen, 54
—— electrotypes, 18
—— glass, 131
Grenet battery, 262
Grey, dyeing woollen, 54
Grindstone, artificial, 373
Grove battery, 262
Gum mucilage, 28
Gun-barrels, browning, 19
Guncotton, 111
Gun metal, 4
Gunpowder, 112
—— components, 112
—— damaged, for fireworks, 94
—— drying, 113
—— equalising, 113
—— glazing, 113
—— granulating, 113
—— mixing, 113
—— pulverising, 113
Guttapercha moulds, 367, 369

HAIRWOOD GRAINING, 104
Hamerton's brush etching, 75
Hamerton's negative etching, 76
—— positive etching, 77
Hands, cleansing, 32
Hansen printing process, 210
Hardening tools, 114
Hats, cleansing, 32
Headbanding books, 11
High relief plating, 369
Hog hair tools, 132
Holding graver, 64
Horn polishing, 378
—— to imitate tortoiseshell, 127
Hydroquinone, 189

IMPASTING PAINTINGS, 136
Impervious cement, 28
Impression metal, 4
Incombustible paper, 142
Incrustations, boiler, 8
Indelible pencil, 42
Indian ink, 39
Indianite cement, 28
Indigo extract, 52
Indoor portrait photos., 180
Ink, diamond writing, 101
—— Indian, 39
—— lithographic, 58
Inking roller for stones, 59
Inlaid work, cleansing, 31
Inlaying mother-of-pearl, 127
Iridium plating, 306
Iron, brass for, 264
—— bronzing, 18, 267
—— case-hardening, 114
—— cleaning, 254
—— etching on, 79
—— galvanising, 359
—— malleable, 114
—— pipes, tinning, 357
—— plating, 306
—— polishing, 380
—— pots, cement for, 28
—— railings, cement for, 28
—— rust joints, 28
—— saucepans, tinning, 357
—— silvering, 350
—— tempering, 114
—— tinning, 356
—— wire, tinning, 357
Ivory, artificial, 115
—— bleaching, 6
—— cements, 29
—— defective, 115
—— flexible, 115
—— mounting, 115
—— paper, 142
—— polishing, 378
—— preparing for miniature painting, 115

JAPANNERS' GILDING, 293
—— gold size, 135
Jet cement, 29
Jewellers' cement, 25
Jewellery, cleansing, 32
Journal boxes, 4

LACE BLEACHING, 7
Lake crayons, 33
Lamp, engravers', 61

Lamp, etching, 66
Landscape photos. by moonlight, 236
Lathe for scratch-brushing, 257
—— polishing in, 379
Lathing and plastering, 116
Lavender, dyeing cotton, 47
—— —— silk, 51
—— —— woollen, 54
Lead, brass for, 264
—— cleaning, 254
—— plating, 306
Leather cement, 29
—— gilding, 297
Lenses, arranging for portrait, 163
—— photographic, 157
Lettering books, 12
—— drawings, 37
Letters, gilding, 303
Light, artificial, for photography, 167
—— for dark rooms, 151
Lightning paper, 93
Lilac, dyeing cotton, 47
—— —— silk, 51
—— —— woollen, 54
Linen, mounting drawings on, 34
—— transparent painting on, 130
Lining oil paintings, 136
Liquid glue, 27
Lithographic chalk, 58
—— ink, 58
—— stones, 57
—— transfer paper, 58, 143
Lithographs, transferring, 58
Lithography, 57
London cement, 29
Looking glasses, 341
Lutes, fire, 26

MAGNESIUM LIGHTS, 167, 190
Mahl stick, 132
Mahogany graining, 103, 104
Malleable iron, 114
Manifold writing paper, 143
Manuscripts, renewing, 42
Maple graining, 103, 104
Marble cement, 29, 125
—— cleansing, 32, 124
—— imitation mosaic, 123
—— mastic, for repairs, 121
—— mounting, 120
—— repairing, 125
—— restoring colour, 125
—— sculpture by acids, 121
—— selecting, 120
—— stucco, 122
—— veneering on boxes, 121
—— —— —— metals, 120
—— —— —— wood, 120
—— —— —— zinc, 120
—— wax for preserving, 123
—— working, 118
Marbling, 109
—— books, 14
—— brushes, 14
—— colours, 14
—— patterns, 15
—— rods, 14
—— skimmer, 14
—— sprinkling book edges, 16
Marbling trough, 14
Marié-Davy battery, 262
Marine glue, 28
Masons' mastic, 122
Mastic, cement, 122
—— for repairing marble, 121
—— masons', 122
Medals, 4
—— bronze, 3
—— bronzing, 268
Meerschaum cement, 29
Megilps, 135
Melting glue, 27
Mercuro-uranotypes, 226
Mercury fulminate, 97
—— gilding, 273
—— plating, 308
Metallising graphite, 364
—— pottery, 365
Metals and wood cement, 30
—— cleansing, 32
—— —— by acids, 250
—— polishing, 380
—— recovering waste, 394
—— veneering marble on, 120
Microscopic slides, photos. for, 231
Mill picks, tempering, 115
Miniature painting on ivory, 115
Mirrors, silvering, 341
Moonlight photographs, 236
Mordanting wicks, 22
Mordants, 45
Mosaic gold, 19
—— imitation marble, 123
Mother of pearl, 126
—— —— —— cement, 29
—— —— —— polishing, 381
Moulding by hand, 368
—— candles, 23
—— in press, 367
—— in stove, 368
—— undercut, 368
Moulds, fusible metal, 366
—— gelatine, 367
—— guttapercha, 367
—— impervious, 365
—— plaster of Paris, 366
—— stearine, 366
—— wax, 366
Mounting board for photos., 202
—— drawings on linen, 34
—— engravings, 42
—— photos., 198
Mouth glue, 28
Muntz metal, 4
Muriate of tin, 53

NATURE PRINTING, 227
Negatives, enlarging, 170
—— grained, 172
—— rain stained, 174
—— reducing intensity, 194
—— repairing broken, 173
—— retouching enlarged, 172
—— washing apparatus, 176
Nickel chloride, 312
—— oxide, 317
—— plating, 310
—— sulphate, 312

Nielled silver, 339
Nitre, spirit of, 6
Nitric acid, etching, 67
Nitro-glycerine, 127

Oak Graining, 103, 105
Oil colour painting, 132
—— gilding on wood, 293
—— painting, 134
—— sketching paper, 134
Olive dyeing cotton, 49
—— —— woollen, 53, 54
Orange dyeing cotton, 49
—— —— silk, 52
—— —— woollen, 55
—— staining glass, 130
Organ pipe metal, 4
Ormolu, 4
—— gilding, 287
Ornamenting books, 11
Over graining, 107
Ozokerit, 22

Paint Brushes, 132
—— gilding, 297
Painting canvas, 133
—— colour harmony, 138
—— easel, 132
—— fresco, 129
—— glass, 130
—— grounds, 134
—— oil colour, 132
—— oils, 134
—— on ivory, 115
—— —— linen, transparent, 139
—— palettes, 132
—— plaster, 138
—— rest, 132
—— sign boards, 139
—— vehicles, 134
—— water-colour, 141
—— wirework, 142
—— zinc, 142
Paintings, glazing, 135
—— impasting, 136
—— lining old, 136
—— preserving scaled or cracked, 137
—— scumbling, 136
—— varnishing, 137
Palettes, 132
Palladium plating, 318
Paper, bleaching, 7
—— bronzing, 18
—— casts from the antique, 146
—— enamelled, 142
—— hanging, 144
—— —— gilding, 297
—— incombustible, 142
—— ivory, 142
—— lightning, 93
—— lithographic transfer, 58, 143
—— manifold writing, 143
—— oil sketching, 134
—— photographic, preparing, 174
—— powder, 143
—— process stereo plates, 5
—— staining, 144
—— to parchment, uniting, 42
—— tracing, 42, 67
—— transfer, 43
Paper, transferring, 67
—— transparent painting on, 139
Papier mâché, 146
Parallel rule, using, 37
Parchment paper, 42
—— —— cement, 30
—— staining, 148
—— to paper or wood, uniting, 42
—— vegetable, 42
Paste, bookbinder's, 30
—— for paper hanging, 145
Pavements, 148
Peach dyeing woollen, 54
Pearls, cleansing, 32
Pencilling a drawing, 37
Pencils, cutting, 35
—— for water-colour painting, 141
—— indelible, 42
Pewter, brass for, 264
—— burnishing, 375
—— silvering, 341
Pharaoh's serpents, 95
Phosphorus, dissolving, 366
Photography, 149
—— acid sulphite, 196
—— argentometer, 167
—— arranging lenses for portraits, 163
—— artificial light, 167
—— autotype, 228
—— calculating length of camera, 169
—— camera, 154, 233
—— carbon printing, 228
—— chemicals, 165
—— cleaning glasses, 164
—— clearing collodion, 174
—— coating celluloid films, 174
—— —— paper with gelatin emulsion, 203
—— collodion-chloride paper, 205
—— —— emulsion, 222
—— colour, 244
—— —— sensitive collodion, 222
—— copying camera, 169
—— —— pictures, 198
—— dark room, 150
—— developing without dark room, 153
—— effect of weather, 167
—— electro-phototypy, 236
—— —— emulsions, 222
—— —— filtering, 216
—— —— washing, 215
—— enlarging negatives, 170
—— fading prints, 192
—— flash light, 190
—— focus, 163
—— for microscopic slides, 231
—— gelatine bromide plates, 212
—— —— chloride paper, 174
—— —— emulsions, 212
—— ghost pictures, 195
—— glass cutting board, 202
—— —— frame, 164
—— grained negatives, 172
—— Hansen printing process, 210
—— home-made camera, 155
—— hydroquinone, 189
—— in aniline colours, 245
—— indoor portraits, 180
—— landscapes, 226
—— —— by moonlight, 236

Photography, lenses, 157
—— light for dark room, 151
—— magnesium lamps, 167
—— making gold and silver salts, 176
—— mercuro-uranotypes, 226
—— miniature paper camera, 154
—— moonlight, 236
—— mounting board, 202
—— —— prints, 198
—— nature printing, 227
—— news letters, 226
—— on silk, 227
—— operating room, 149
—— pinhole pictures, 197
—— plate inspector, 192
—— plates, coating, 217
—— —— drying, 219
—— platinotype, 223
—— platino-uranotype, 226
—— powders, 168
—— preparing plain paper, 174
—— primitive, 245
—— printing plates, 207, 211
—— rack, 192
—— rain-stained negatives, 174
—— rapid dry plates, 173
—— reducing intensity, 194
—— relief plates, 207
—— repairing broken negatives, 173
—— retouching enlarged negatives, 172
—— rocking machine, 203
—— shutter, 165
—— silver prints on drawing paper, 207
—— size of glasses, 164
—— snap shots, 162
—— sodium sulphite, 196
—— softening pictures, 198
—— stereoscopic views, 182
—— stripping films, 183
—— toning paper, 174
—— transfer paper, 238
—— transferring, 173
—— transparent positives, 169
—— trays, 191
—— twin lens camera, 183
—— views, 226
—— washing negatives, 176
—— yellow stains, 173
Photo-lithographic paper, 238
—— —— transfers, 237
—— -micrographic camera, 233
—— —— paper, 235
—— -micrographs, 231
—— —— on gelatine plates, 231
—— —— simple apparatus for, 233
—— -zincography, 240
Picks, tempering, 115
Picture frames, burnished gilt, 301
—— —— cleaning, 301
—— —— composition, 146
—— —— gilding, 298
—— —— moulding, 300
—— —— re-gilding, 301
Pictures, cleansing, 32
Pinchbeck, 4
Pinhole photos., 197
Pink dyeing cotton, 48
—— —— silk, 51
—— —— woollen, 54
Pin mordant, 45
—— wheels, 94
Pipe metal for organs, 4
Plaster, bronzing, 18, 268
—— cast polishing, 381
—— moulds, 366
—— painting, 138
Plastering, 116
Plate, cleansing, 32
—— glass, 103
—— powders, 371
Plated silver, 333
Plates, photo. printing, 207
Plating, 250
—— amalgamating salt, 262
—— antimony deposits, 263
—— batteries, 257
—— bismuth deposits, 263
—— brass deposits, 263
—— bronzing, 266
—— cleaning copper, 250
—— —— iron, 254
—— —— lead, 254
—— —— silver, 255
—— —— steel, 255
—— —— tin, 254
—— —— zinc, 255
—— cobalt deposits, 270
—— finishing up, 370
—— galvanoplastic, 370
—— copper deposits, 270
—— filling with brass solder, 369
—— gilding, 273
—— gold baths, 370
—— high relief, 369
—— iridium, 306
—— iron, 306
—— kinds of deposit, 259
—— lathe for scratch-brushing, 257
—— lead, 306
—— mercury, 308
—— nickel, 310
—— non-metals, 364
—— palladium, 318
—— platinum, 319
—— removing mould, 370
—— scratch-brushing, 256
—— silver, 328
—— —— baths, 370
—— steel, 306
—— thick deposits, 361
—— tin, 352
—— vats, 262
—— zinc, 353
Platinising glass, 327
Platinotype photography, 223
Platino-uranotypes, 226
Platinum fulminate, 98
—— plating, 319
—— recovering, 395
Plugging wood engravings, 65
Plumbago, metallising, 364
Plumbers' cement, 30
Polished plate glass, 103
Polishing, 371
—— book edges, 13
—— French, 375
—— materials, 371
—— wheels, 372

Pollard oak graining, 106
Porcelain, gilding, 287, 295
Portable glue, 28
Portfires, 85
Pots and pans, cement for, 28
Pottery bodies, 383
—— coloured clays, 385
—— colours under glaze, 385
—— enamels, 386
—— fluxes, 386
—— gilding, 303
—— glazes, 391
—— metallising, 365
—— printing oil, 393
—— stains, 393
Powders, bronzing, 19
Preserving scaled or cracked paintings, 137
Pressing books, 9
Primrose dyeing woollen, 55
Primuline photography, 245
Printed books, bleaching, 7
Printing on stone, 58
—— plates, photo., 207
—— rollers, 393
Prints, bleaching, 7
—— cement for, 30
Proofs, engraving, 65
Pugging floors, 118
Purple dyeing cotton, 48
—— —— silk, 51
—— —— woollen, 54
—— glass, 131
Putty powder, 371
Pyrotechnics, 79

QUEEN'S METAL, 4
Quickmatch, 87, 93

RAILINGS, IRON, CEMENT FOR, 28
Razor paste, 371
Recovering waste metal, 394
Red crayons, 34
—— dyeing cotton, 48
—— —— silk, 51
—— —— woollen, 54
—— mordant, 45
—— staining glass, 130
Relief photo-plates, 207
Rendering fat, 20
Renewing manuscripts, 42
Retinning copper pans, 355
Ribbed plate glass, 103
Rivet metal, 4
Rockets, 79
—— cartridges, 79
—— cases, 79
—— charging, 81
—— compositions, 82
—— head, 81
—— loading, 81
—— mould, 80
—— pot, 81
—— priming, 81
—— sizes, 79
—— sticks, 82
Roman candles, 86
Room for water-colour painting, 141
Rose colour glass, 131
—— dyeing silk, 51
—— —— woollen, 54
Rosewood graining, 104, 106
Rosin ground engraving, 75
Rottenstone, 66
Rouge, 371
Rubber cement, 30
—— piecing, 407
—— solutions, 407
—— solvents, 407
Ruby dyeing cotton, 48
—— —— woollen, 54
Rust, 408
—— joints, 28
—— preventing, 408
—— removing, 408

SABLE BRUSHES, 133
Salmon dyeing silk, 52
Saltpetre for fireworks, 94
—— —— gunpowder, 112
Satinwood graining, 103, 106
Saucepans, tinning, 357
Scarlet dyeing cotton, 48
—— —— silk 52
—— —— woollen, 55
Scratch-brushing, 256
Scumbling paintings, 136
Serpents, pyrotechnic, 94
Sewing books, 9
Shading drawings, 40
Shadow pictures, 195
Sheet glass, 103
Shells, polishing, 381
Signs, gilding, 303
—— painting, 139
Silk, bleaching, 8
—— dyeing, 49
—— photography on, 227
—— spirits, 52
Silver and ammonia fulminate, 98
—— baths, 370
—— bright lustre, 337
—— bronze powders, 19
—— burnishing, 338, 375
—— Chinese, 3
—— cleansing, 32, 255
—— dissolving, 351
—— engraving, 56
—— frosted, 337
—— fulminate, 98
—— German, 3
—— gilding, 288
—— imitation, 4
—— nielled, 339
—— nitrate, 328
—— oxidised, 339
—— plating, 328
—— —— amateur bath, 329
—— —— antique, 339
—— —— cold, 329
—— —— electro-bath, 334
—— —— hot, 320
—— —— in pot, 332
—— —— solutions, 328
—— —— powder, 332
—— —— presenting yellow, 338
—— —— weighing deposit, 333
—— —— with foil, 331
—— powder, 288
—— prints on drawing paper, 207

Silver rain, 85
—— recovering, 396
—— salts, making, 176
—— varnished leaf, 338
Silvering brass, 340
—— Britannia metal, 341
—— clock dials, 341
—— copper ingots, 341
—— curved glass, 349
—— glass, 341
—— —— globes, 349
—— —— with silver salts, 345
—— iron, 350
—— looking-glasses, 341
—— old, 339
—— on solder, 351
—— pewter, 341
—— reflectors, 351
—— specula, 343
—— thermometer scales, 351
—— watch-glass, 349
Size, gold, 291
Sketching paper, 134
Slate dyeing silk, 52
—— —— woollen, 55
—— enamelling, 125
—— polishing, 381
Smee battery, 262
Snap shots, 162
Snuffless candles, 24
Sodium sulphite, acid, 196
Softening cast iron, 114
—— files, 114
Specula, silvering, 343
Speculum metal, 4
Spirit of nitre, 6
Spirits, aquatinta, testing, 73
Springs, tempering, 115
Squibs, 94
Staining glass, 130
—— paper, 144
—— parchment, 148
Stains from marble, removing, 125
—— pottery, 393
Stars, 82
—— blue, 84
—— coloured, 83
—— crimson, 84
—— green, 84
—— rose, 84
—— tailed, 83
—— violet, 84
—— white, 85
—— yellow, 84
Statuary, bronze, 3
—— metal, 5
Stearine moulds, 366
Steel, cleansing, 32, 255
—— cylinders, engraving, 61
—— engraving, 59
—— etching on, 78
—— gilding, 288
—— plating, 306
—— polishing 380
—— tempering, 114
Stencilling on glass, 102
Stencil plates, cutting, 40
—— —— using, 41
Stereoscopic views, 182
Stereoscopic views with ordinary camera, 183
Stereotype metal, 5
Stippling, 78
Stone, drawing on, 58
—— dyeing cotton, 48
—— —— silk, 52
—— —— woollen 55
—— engraving, 57, 59
—— etching in, 58
—— imitation woodcuts on 60
—— inking roller, 59
—— lithographic, 57
—— -mason's cement, 30
—— printing on, 58
—— removing transfer, 59
—— transferring from copper to, 59
Stopping for French polishing, 375
Stopping-out varnish, 66
Straightedge, testing, 36
Straw dyeing silk, 52
—— —— woollen, 55
Stripping photo. films, 183
Strontia nitrate, 85
Stucco, 117
—— marble, 122
Sulphur for gunpowder, 112
Swain's photo-zinco works, 242
Swords, cleansing, 33

Tallow Boiling, 21
—— clarifying, 21
—— rendering, 20
Tamtams, 3
Tar pavement, 149
Tempering iron and steel, 114
—— picks and chisels, 115
—— springs, 115
Tightening casks, 1
Tin, brass for, 264
—— bronzing, 269
—— cleaning, 254
—— deposit, colour of, 354
—— muriate, 53
—— oxide, 371
—— plate, 357
—— —— crystallised, 354
—— plating, 352
—— recovering, 402
Tinning, 352
—— brass, 354
—— —— wire, 356
—— cold, 353
—— copper, 354
—— —— pans anew, 355
—— electro, 353
—— iron, 356
—— —— pipes, 357
—— —— saucepans, 357
—— —— wire, 357
—— metal, 5
—— small articles, 353
—— zinc, 358
Tint tools, 62
—— —— preparing, 63
Tombac, 5
Tools, hardening, 114
Tortoiseshell, imitation, 127
—— polishing, 378
Touch-paper, 87

Tourbilions, 90
Tracing, 67
—— paper, 42, 67
Tracings, colouring, 40
Transfer paper, 43, 238
—— —— lithographic, 58, 143
—— removing from stone, 59
Transferring engravings to glass, 102
—— etching, 68
—— from copper to stone, 59
—— lithographs, 58
—— paper, 67
—— photographs, 173
Transparent candles, 24
—— painting on linen, 139
—— —— on paper, 139
Turned work, polishes for, 377
Turner's cement, 30
Turpentine etching varnish, 66
Tutania, 5
Type metal, 5

UNDER-CUT MOULDING, 368
Ungilding, 305
Using cements, 31

VARNISH FOR PRESERVING MARBLE, 123
—— stopping out, 66
—— turpentine, etching, 66
Varnishing paintings, 137
Vegetable parchment, 42
Vehicles, painting, 134
Vellum, gilding on, 305
Veneering marble on boxes, 121
—— —— on metals, 120
—— —— on wood, 120
—— —— on zinc, 120
Vulcanite, 407
—— polishing, 381

WASTE METAL, RECOVERING, 394
Watch parts, gilding, 289
Water colour brushes, 141
—— —— painting, 141
—— gilding, 293
Waterproof cement, 25
Watt battery, 262
Wax, bordering, 66
—— for preserving marble, 123
—— moulds, 366
Weather and photography, 167
White acid, 101
—— crayons, 33, 34
—— enamel glass, 130
—— metal, 5
Whitening by tin, 354
Wicks, 22
—— mordanting, 22
—— snuffless, 24
Window glass, 102
Wire work, painting, 142
Wood and glass cement, 30
—— bronzing, 19, 269
—— carving polishes, 377
—— cracks, cement for, 31
—— drawing on, 64
—— engraving, 61
—— for engraving, 64
—— oil gilding on, 293
—— to parchment, uniting, 42
—— veneering marble on, 120
—— vessels, cement for, 31
Woodcuts, imitation, on stone, 59
Wool, bleaching, 8
Woollen, dyeing, 53
—— spirits, 55
Writings, gilding, 305

YELLOW CRAYONS, 34
—— dyeing cotton, 48
—— —— silk, 52
—— —— woollen, 55
—— staining glass, 130

YEW GRAINING, 106

ZINC, BRASS FOR, 265
——, bronzing, 270
—— cleaning, 255
—— gilding on, 305
—— painting, 142
—— plating, 358
—— —— brass, 359
—— —— copper, 359
—— —— iron, 359
—— tinning, 358
—— veneering marble on, 120
Zincography, 240
—— printing frames, 242
—— works, 242

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Materials of Construction 75 and 76
Measuring and Folding 76
Mechanical Movements .. 76, 77
Mercury, 77; Metallurgy .. 77
Meter 77, 78
Metric System 78
Mills 78, 79
Molecule, 79; Oblique Arch .. 79
Ores, 79, 80; Ovens 80
Over-shot Water-wheel .. 80, 81
Paper Machinery 81
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Piles and Pile-driving .. 82 and 83
Pipes 83, 84
Planimeter 84
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Railway Engineering .. 85 and 86
Retaining Walls 86
Rivers, 86, 87; Riveted Joint .. 87
Roads 87, 88
Roofs 88, 89
Rope-making Machinery .. 89
Scaffolding 89
Screw Engines 89, 90
Signals, 90; Silver .. 90, 91
Stationary Engine .. 91, 92
Stave-making & Cask Machinery 92
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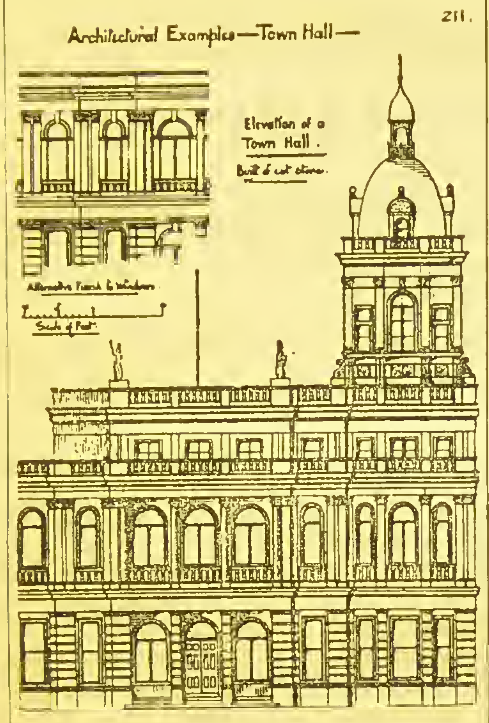
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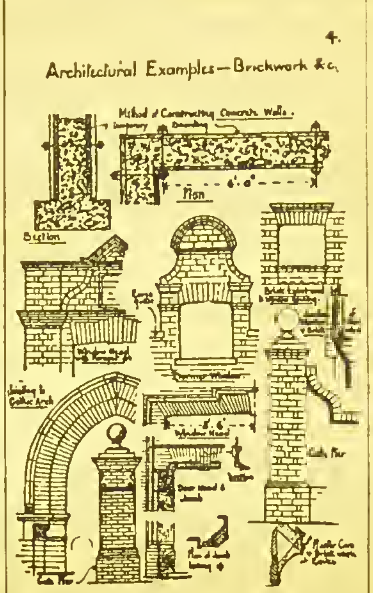
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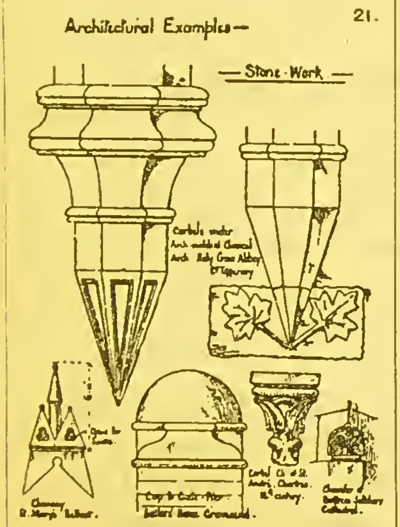

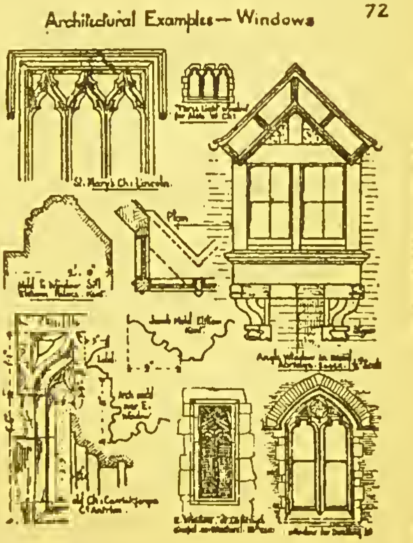

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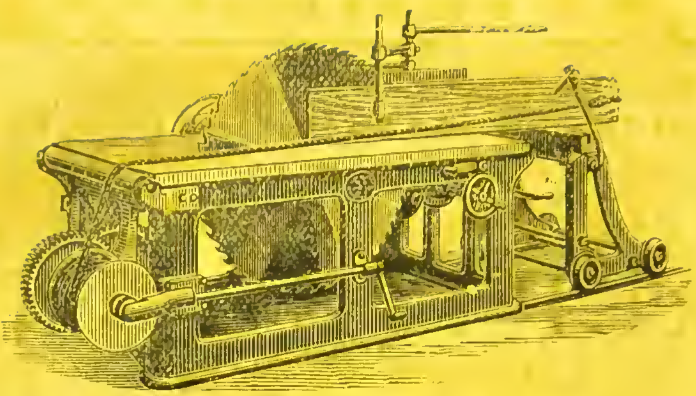

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